THE ENGINEER

JANUARY 23, 1959 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

Pile Driving Plant for Malayan Railways

BSP

This plant is designed for pitching and driving 34" diameter hollow pre-stressed concrete piles 100 ft. long and weighing up to 18 tons. The frame has a height of 95 ft. and is arranged for power raking. It is equipped with an 8 ton single-acting steam hammer, two 6 ton double-drum winches and an oil-fired boiler.

A second plant, with a frame 130 ft. high, was supplied for driving similar piles up to 140 ft.

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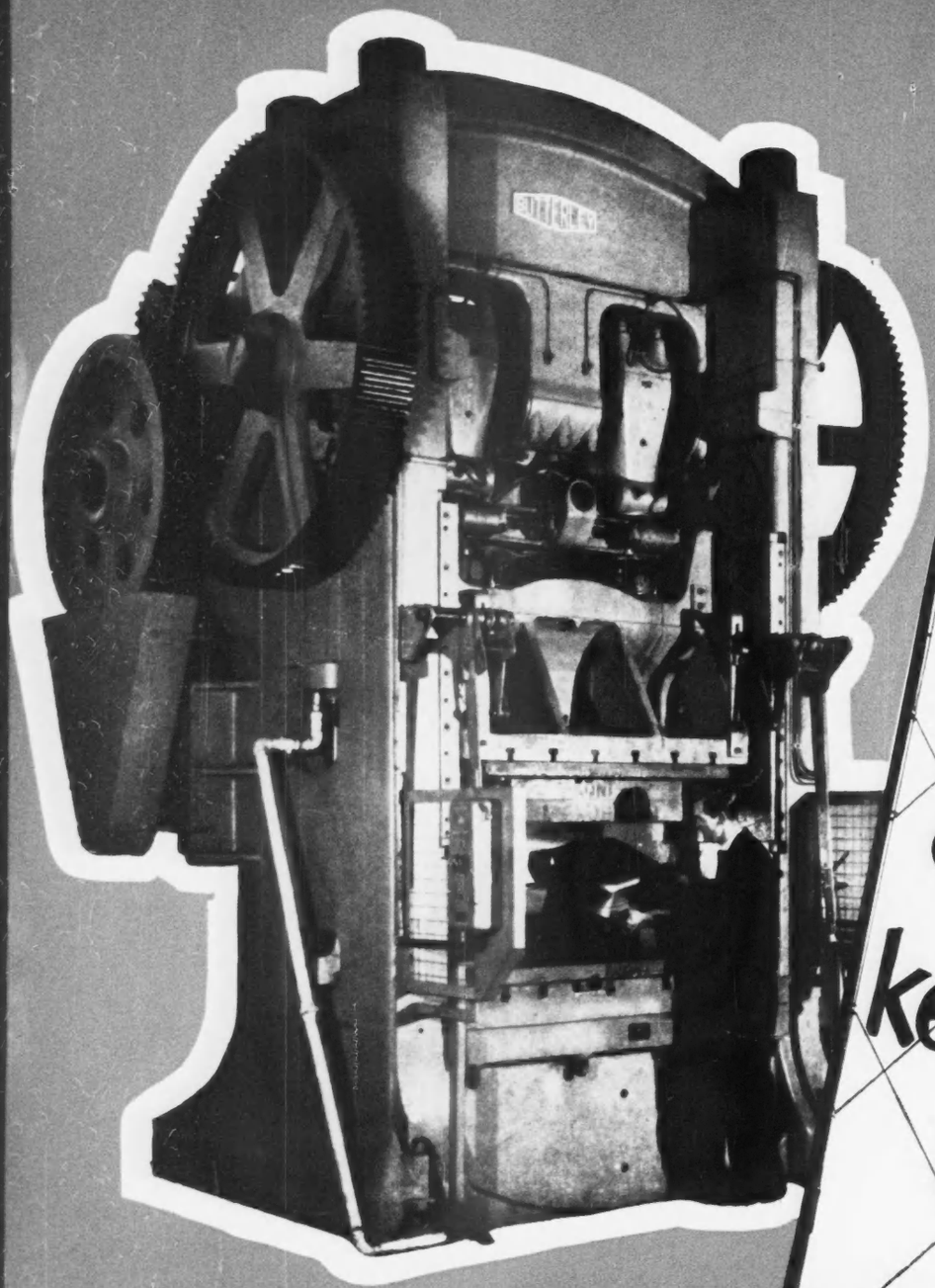

MEEHANITE NEWS

MEEHANITE castings keep costs down

Cast Iron Can Do it-if it's

MEEHANITE

The Dependable Metal

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All castings, even the cast-to-form dies, in this Butterley press are made from Meehanite Iron.

Heavy duty machine tool castings in Meehanite offer cost-cutting advantages such as:

- ★ Absolute soundness under pressure
- ★ Close-grained, homogeneous texture giving high surface finish
- ★ Good machinability and absence of hard spots
- ★ Faster speeds and feeds

Each grade of Meehanite offers special properties—wear resistance, heat resistance, corrosion resistance and ready response to heat treatment. Meehanite castings meet BSS.1452 Grades 10 to 26.

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THE ENGINEER

Established 1856

No. 5374 **JANUARY 23, 1959** VOL. 207

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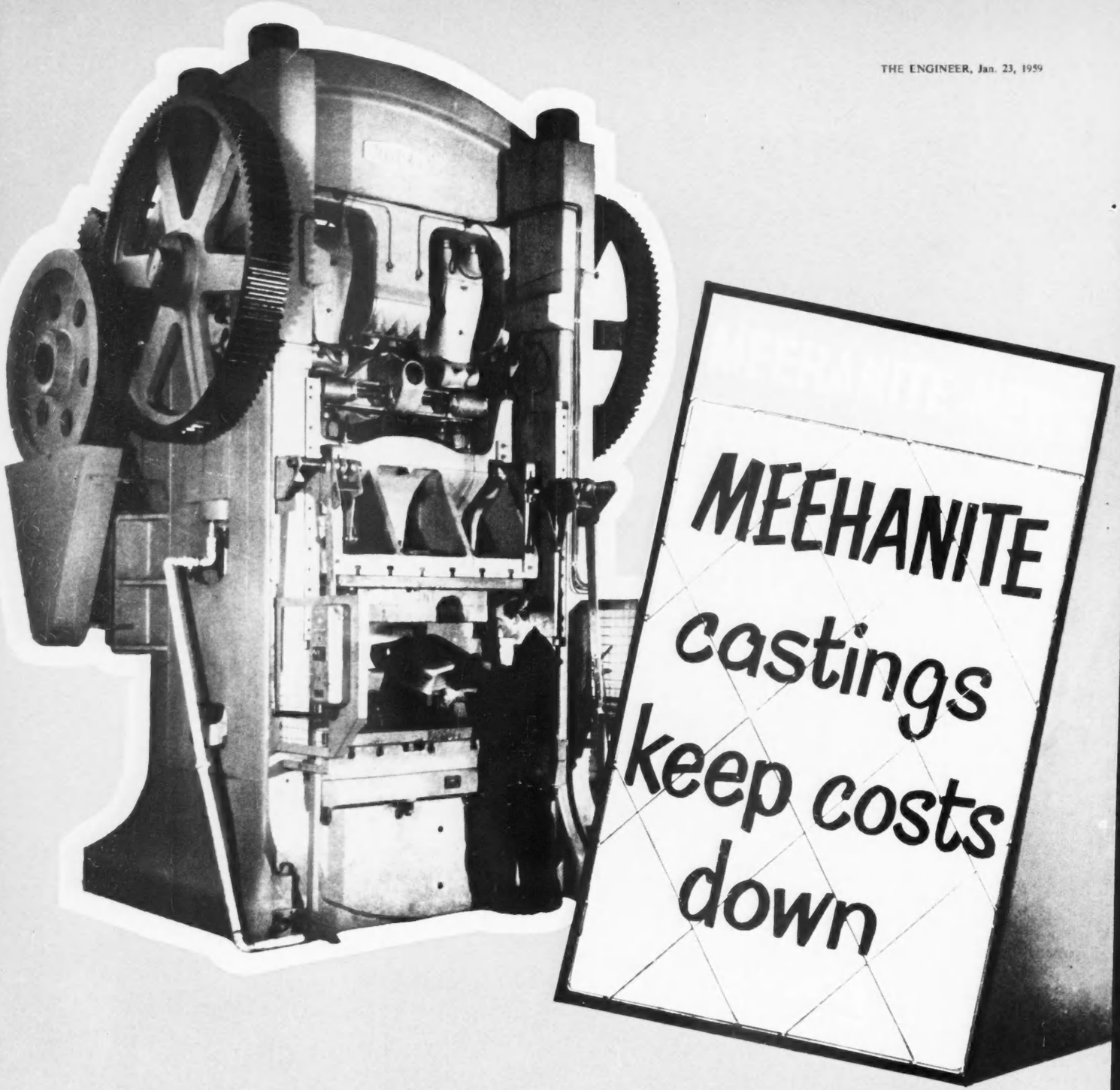

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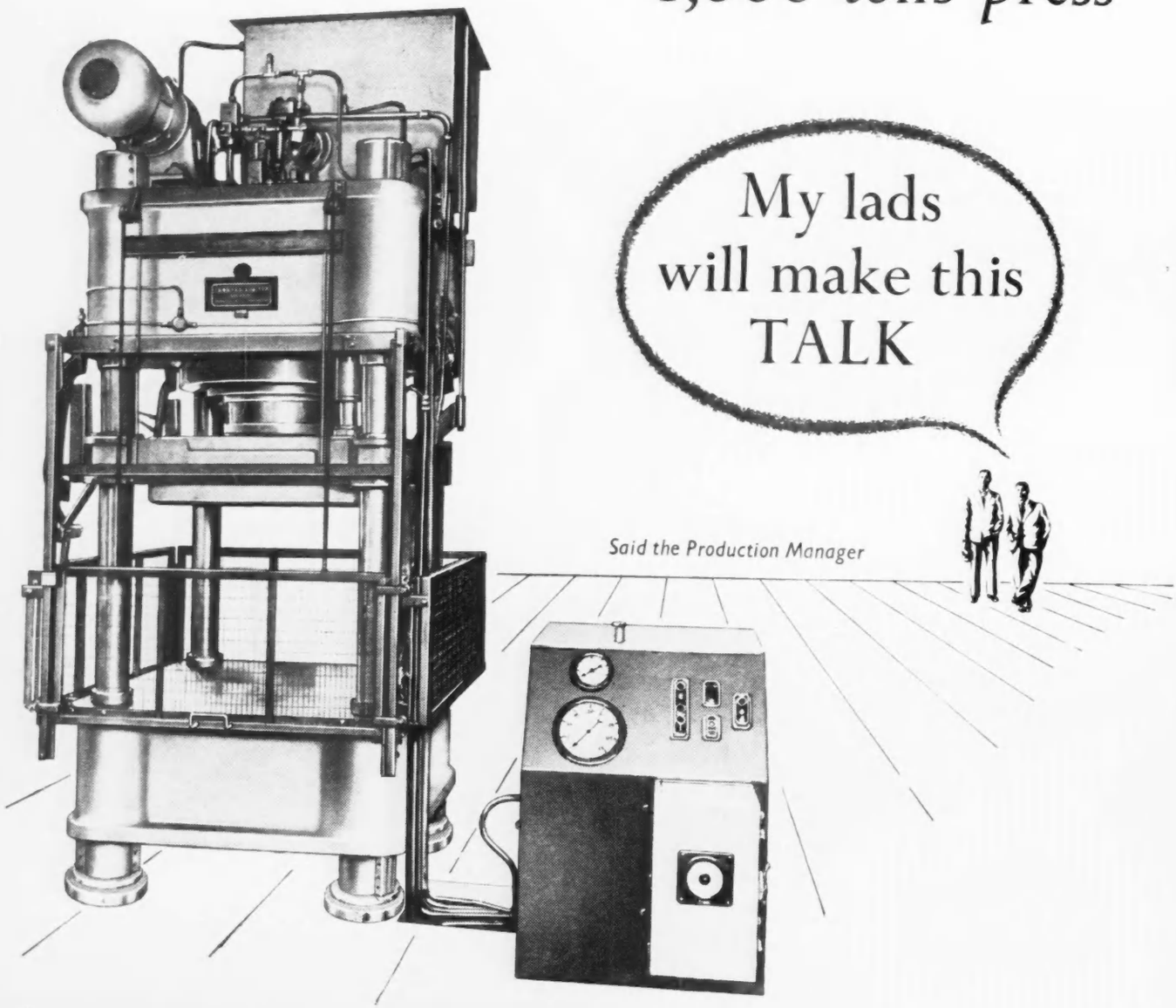

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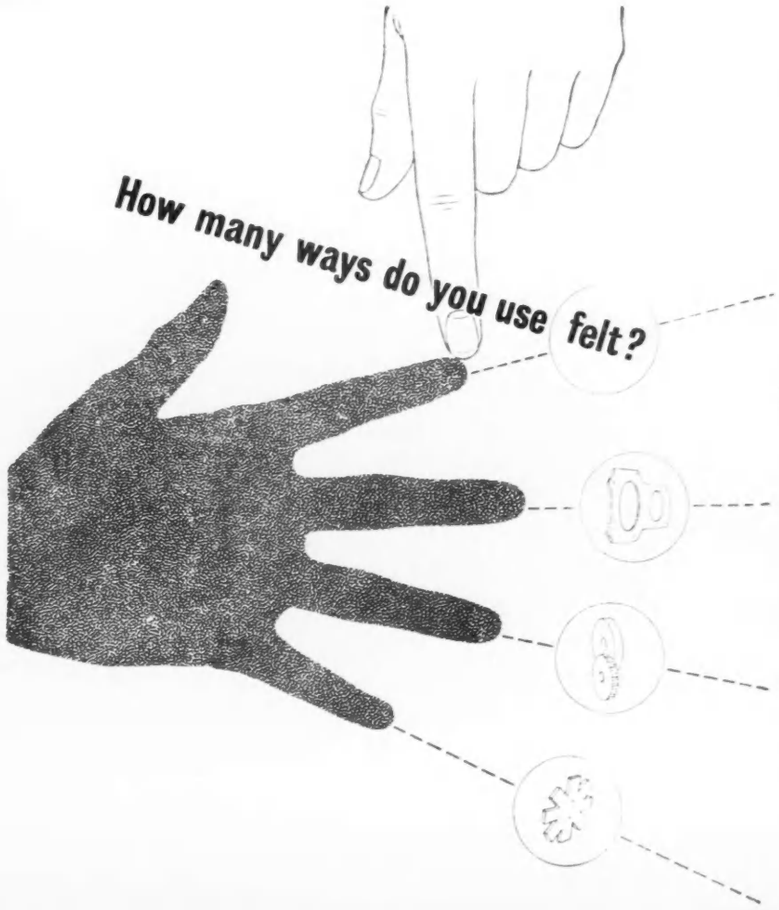

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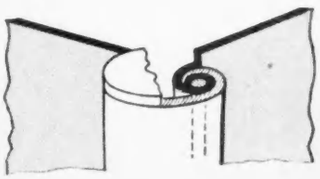
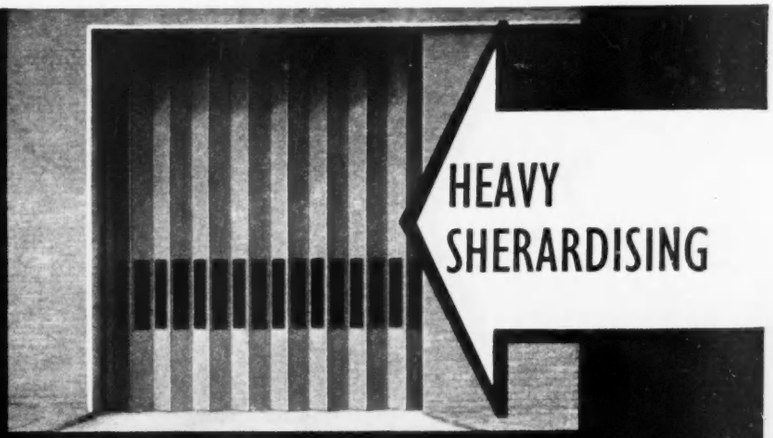


The detail shows the standard manganese bronze or non ferrous alloy hingeing strip arrangement. Curled edges of shutter leaves reinforced with ¼" dia. wire.

HINGEING STRIP IN BRONZE OR ALLOY



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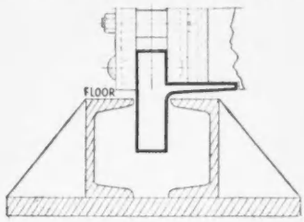

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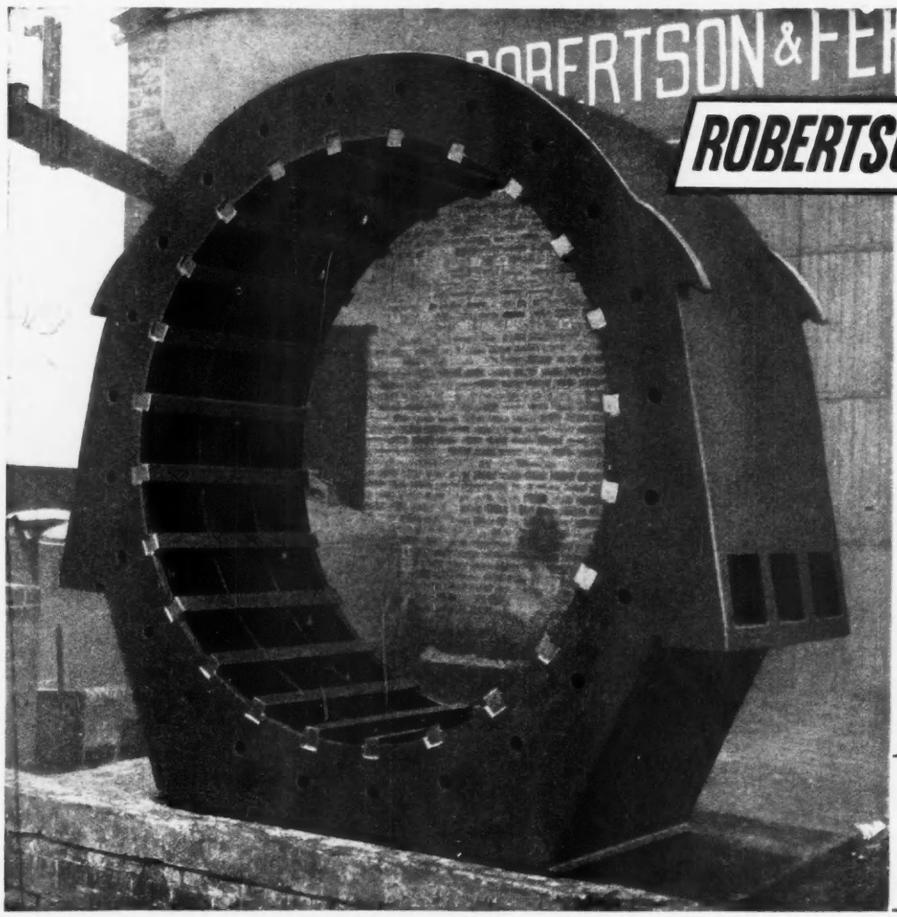

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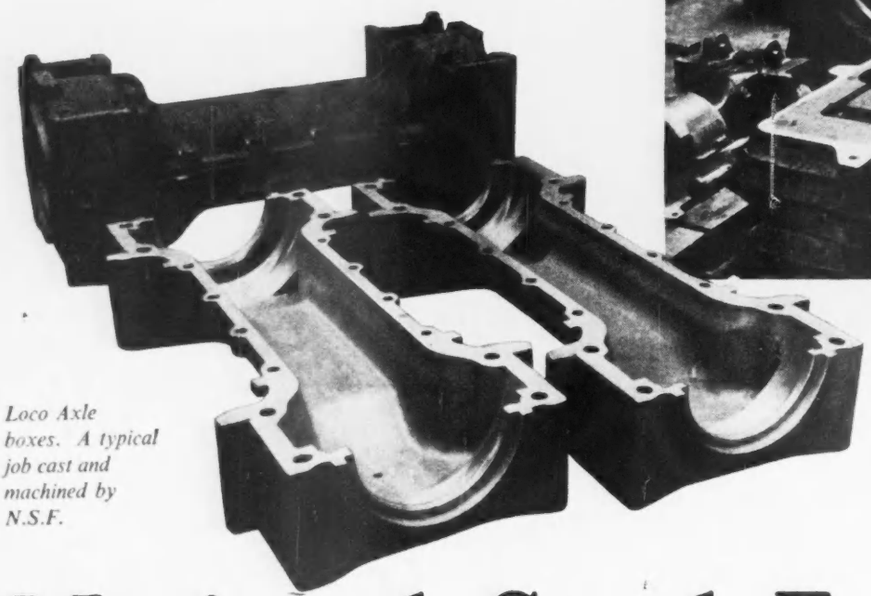

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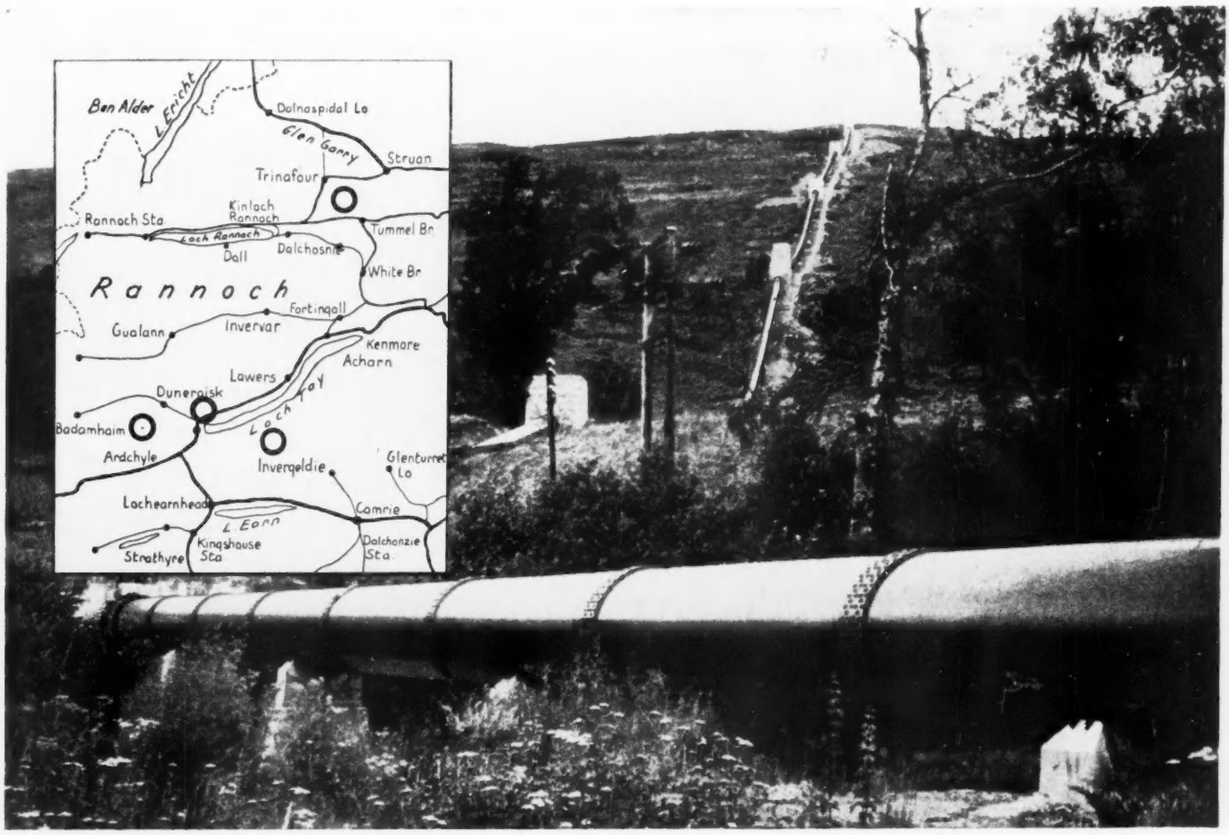

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Up at Lawers in Perthshire, and other places where pipelines of the North of Scotland Hydro-Electric scheme run, engineers have exploited the advantages of Tufnol for bearing pads to support the pipelines. Many of the pads have already given several years of satisfactory service for, due to its inherent physical properties, Tufnol is the ideal bearing material for pipelines.

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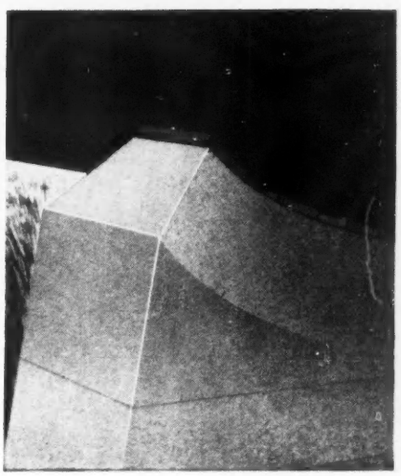

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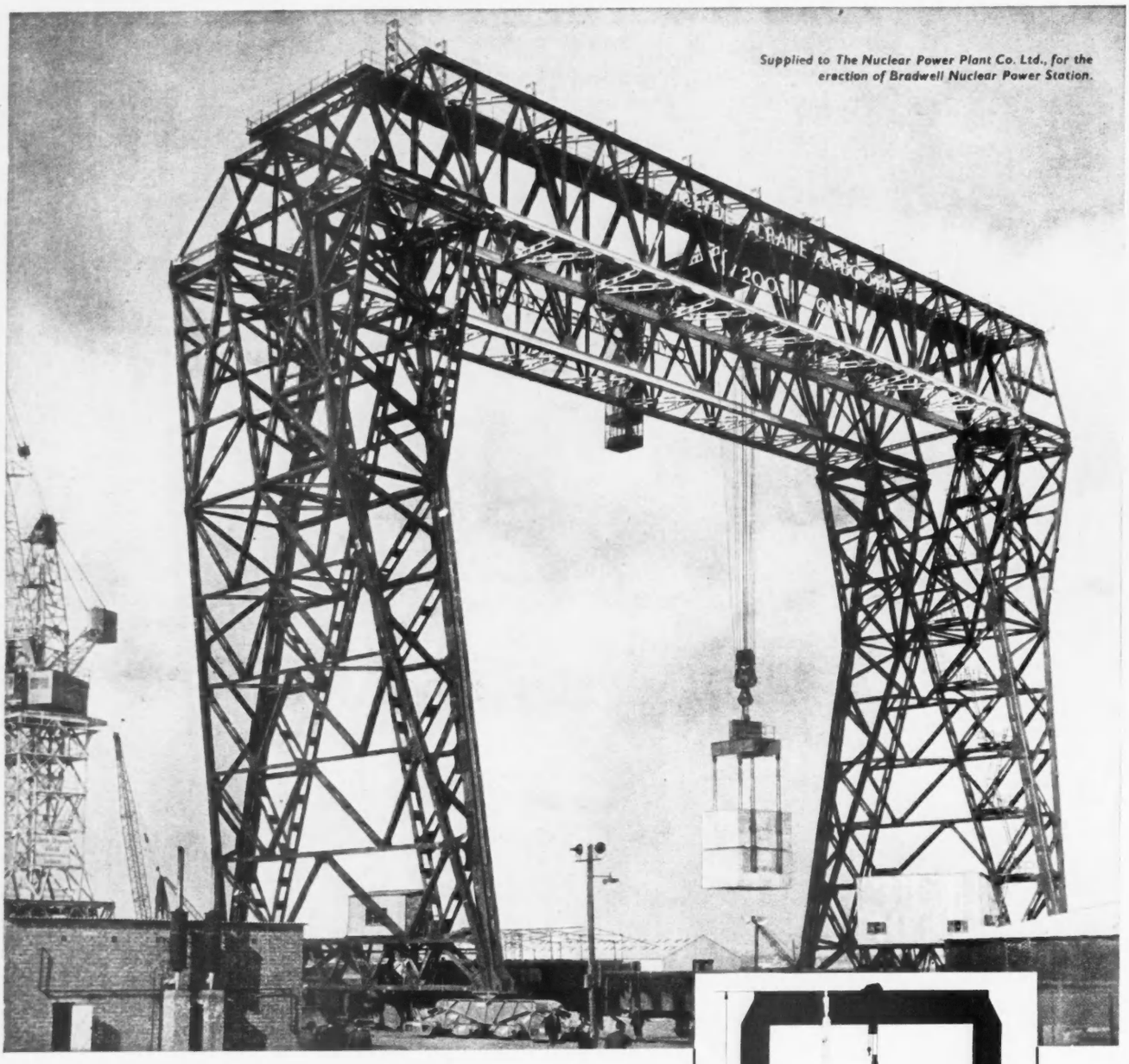

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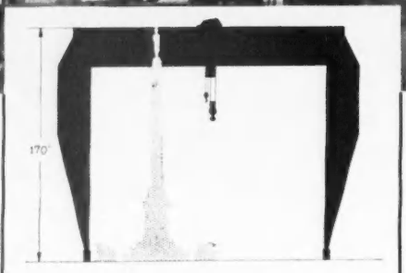

The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.

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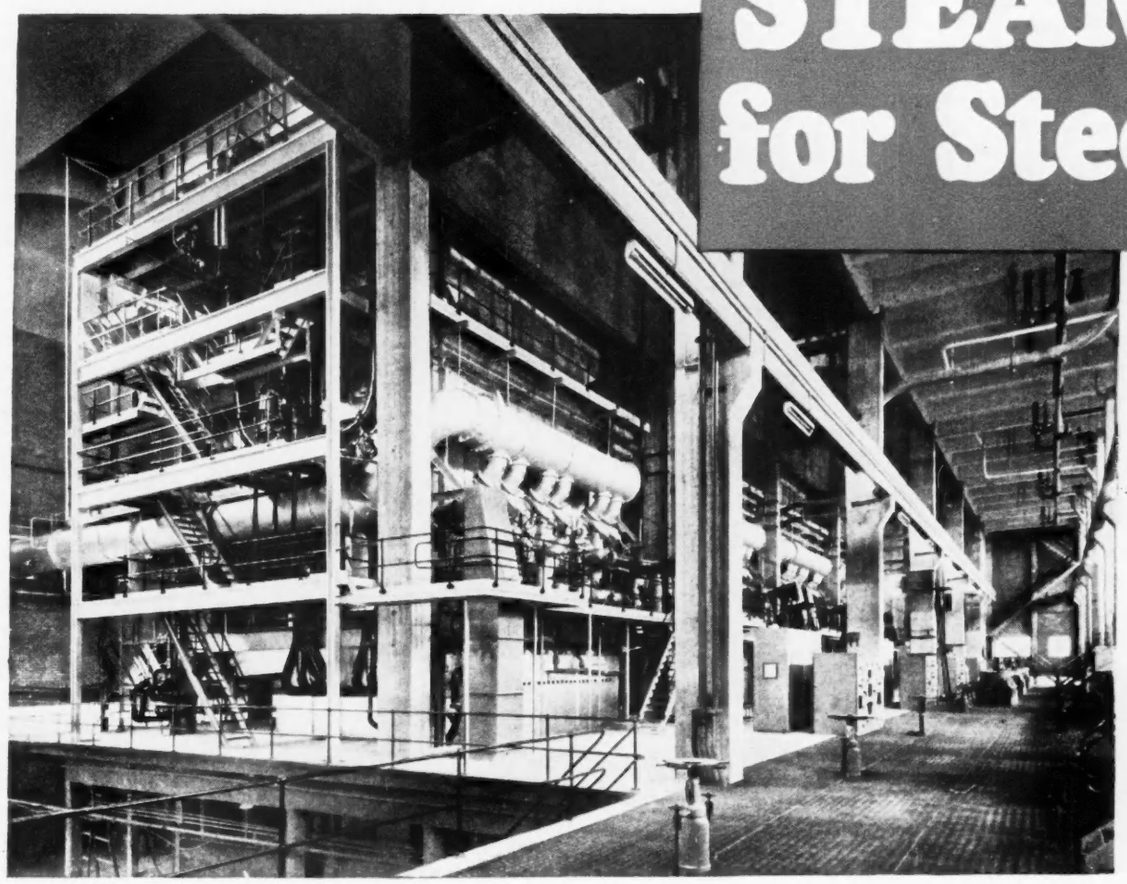

BABCOCK & WILCOX Ltd. are proud to have had an important part in the equipment of the new Colvilles £20,000,000 coke oven, blast furnace and steel-making plant at Ravenscraig, Motherwell, Scotland.

They share a mutual interest in this great plant, as they are themselves considerable users of Colvilles steel for the manufacture of high-pressure boiler drums, and pressure vessels for the oil and chemical industries.

At the new Ravenscraig works, four Babcock Bi-drum boilers, each with an evaporation of 125,000 lb. steam/hr. M.C.R. at 425 lb./sq. in. and 820 F., supply high-pressure steam for electrical power generation and for the operation of turbo-blowers serving the blast furnaces. Provision is also made to supply steam for process purposes. The main fuel for the boilers is blast-furnace gas with a G.C.V. of approximately 98 B.Th.U/cu. ft., at a pressure of 10 in. w.g. Oil burners are also provided for auxiliary or alternative oil-firing and provision has been made for possible future stoker-firing to use coke-breeze from the works coke-ovens.

The contract placed with Babcock & Wilcox Ltd. by The General Electric Company Limited, main contractors for the electrical power plant, covered also the supply of much of the auxiliary plant including the oil-firing installation, oil piping, high-pressure pipework and valves in the boiler-house — including piping to turbo-alternators and turbo-blowers — Bailey automatic boiler control equipment, oil storage and service tanks and steel self-supporting chimneys — a good example of the comprehensive service offered by Babcock & Wilcox Ltd. to industrial steam-users.

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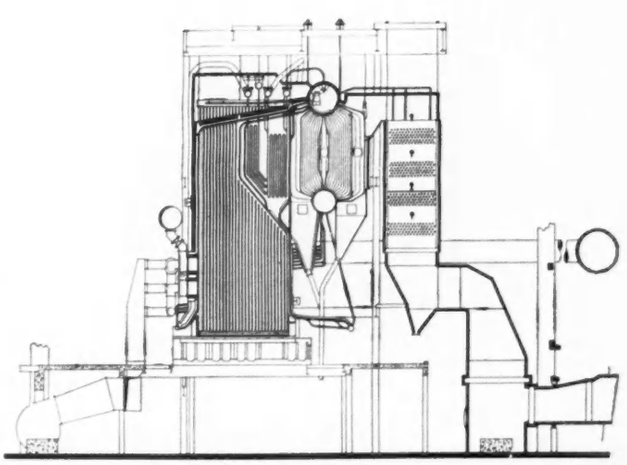

Sectional arrangement of one of the 125,000 lb. / hr. Babcock Bi-drum boilers at the Ravenscraig works.

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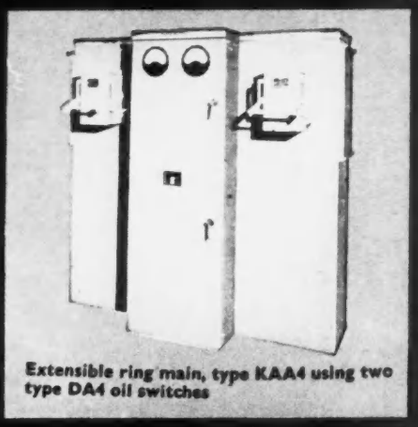
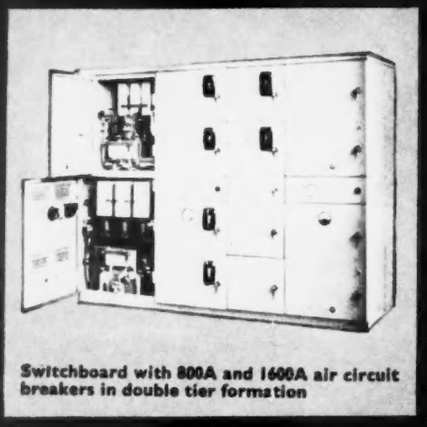


Extensible ring main, type KAA4 using two type DA4 oil switches



Switchboard with 800A and 1600A air circuit breakers in double tier formation

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3.3kV to 11kV—up to 250 MVA at 11kV. With fault-making oil switches in extensible or non-extensible form.

INDOOR AIRBREAK SWITCHGEAR
30 MVA at 400/660V and up to 250 MVA at 3.3kV.

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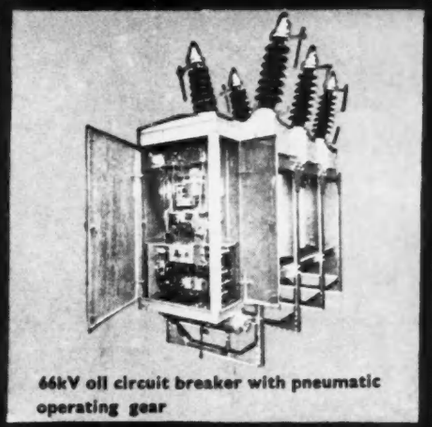
3.3kV to 33kV—up to 1500 MVA at 33kV. Units up to 250 MVA at 11kV available from stock.

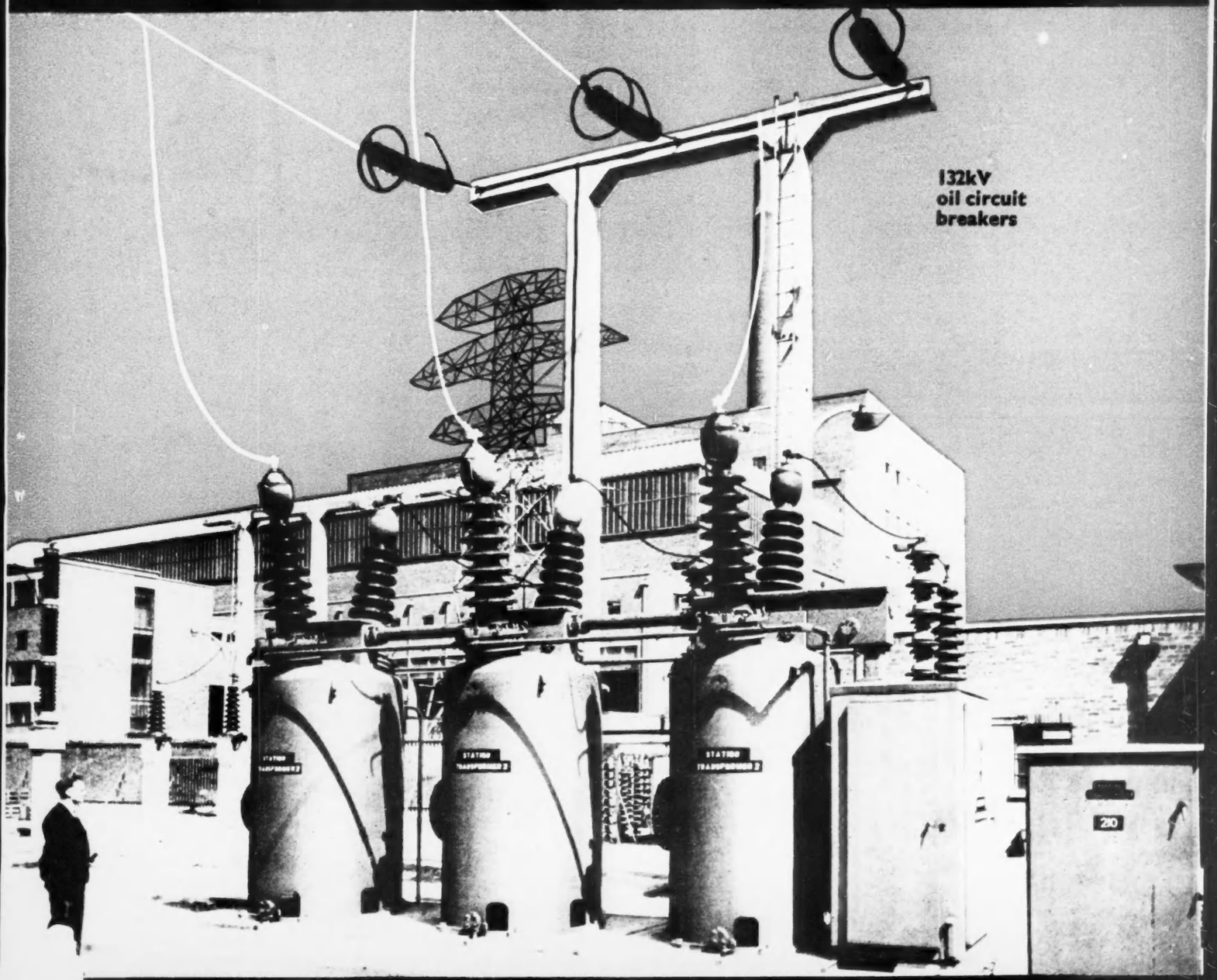
OUTDOOR OIL CIRCUIT BREAKERS
11kV to 132kV—up to 5000 MVA at 132kV. Breakers up to 750 MVA at 33kV available from stock.

You are invited to ask for the Technical Descriptions of the above switchgear

33kV, 750 MVA metalclad switchboard



66kV oil circuit breaker with pneumatic operating gear



132kV oil circuit breakers

G.E.C. power control equipment

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND.

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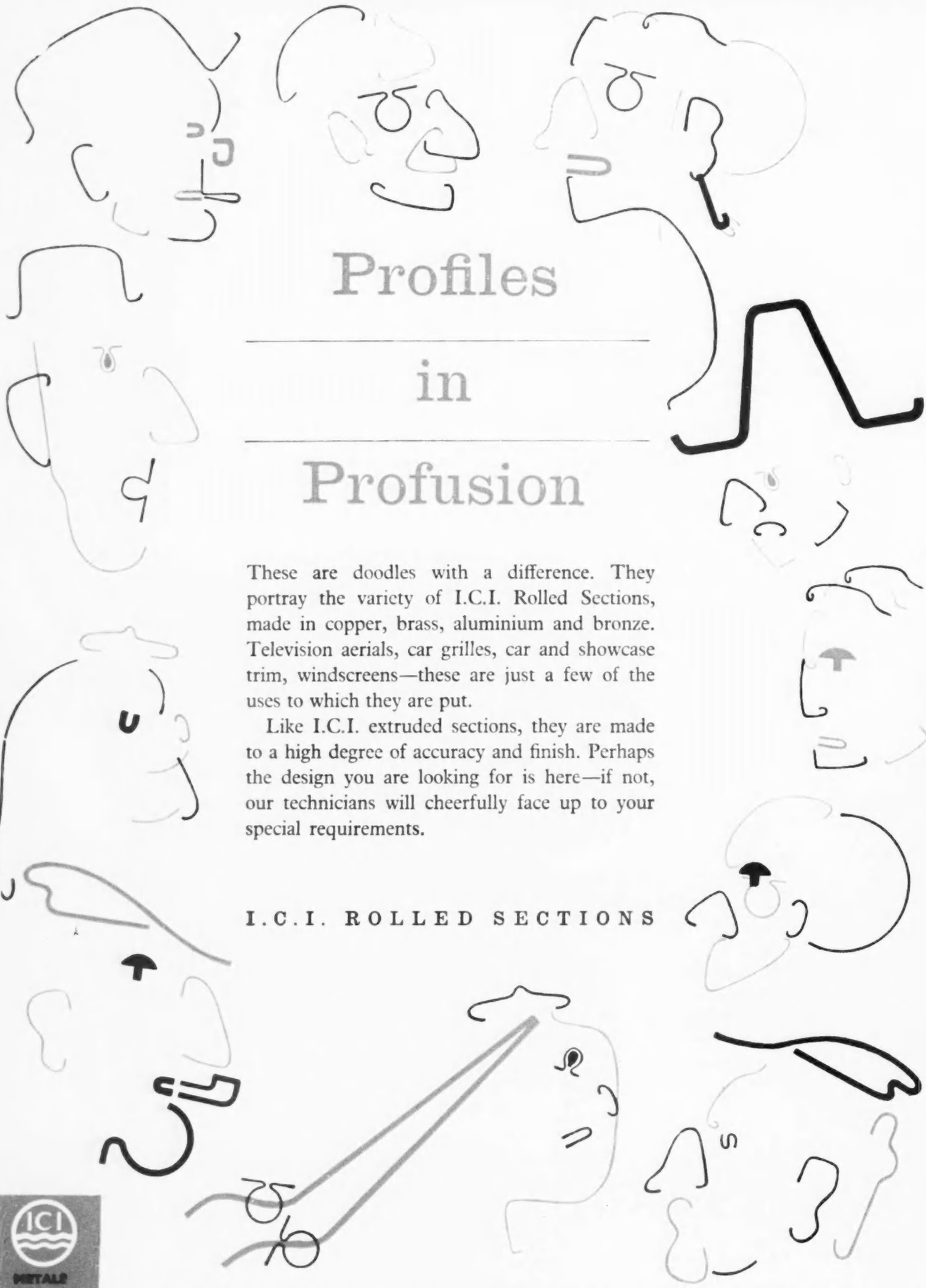

Profiles in Profusion

These are doodles with a difference. They portray the variety of I.C.I. Rolled Sections, made in copper, brass, aluminium and bronze. Television aerials, car grilles, car and showcase trim, windscreens—these are just a few of the uses to which they are put.

Like I.C.I. extruded sections, they are made to a high degree of accuracy and finish. Perhaps the design you are looking for is here—if not, our technicians will cheerfully face up to your special requirements.

I.C.I. ROLLED SECTIONS

ICI METALS DIVISION

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M15

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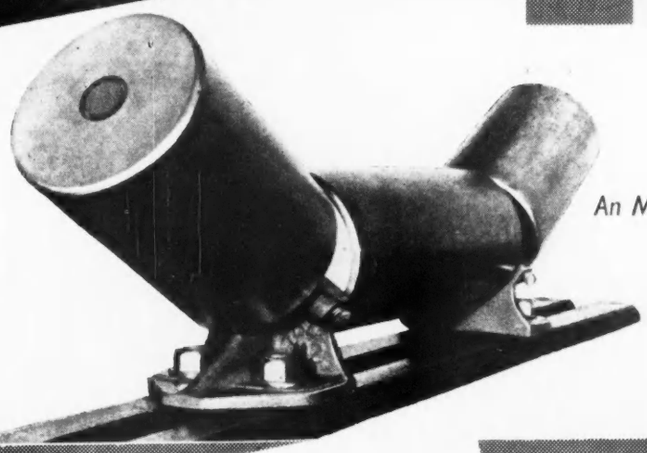

An M&C idler for a 24-in. conveyor belt.

To say that idlers are "sealed for life" is an empty phrase, for how long is "life?" A butterfly's life or an elephant's? M&C idlers are sealed for long life. Put to work as delivered and left to themselves, they will be in the best of health long after others have given up. And M&C seals can be rejuvenated at intervals, new grease driving out the old, making the seals perpetual and multiplying the life of the idlers many-fold.

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By arrangement, the grease gun was not used.
1959, still going strong.

EXAMPLE WITH MAINTENANCE

1943, sealed for first life.
Three-shift running.
Resealed by grease gun at intervals.
1959, aged 16 years, still going strong.
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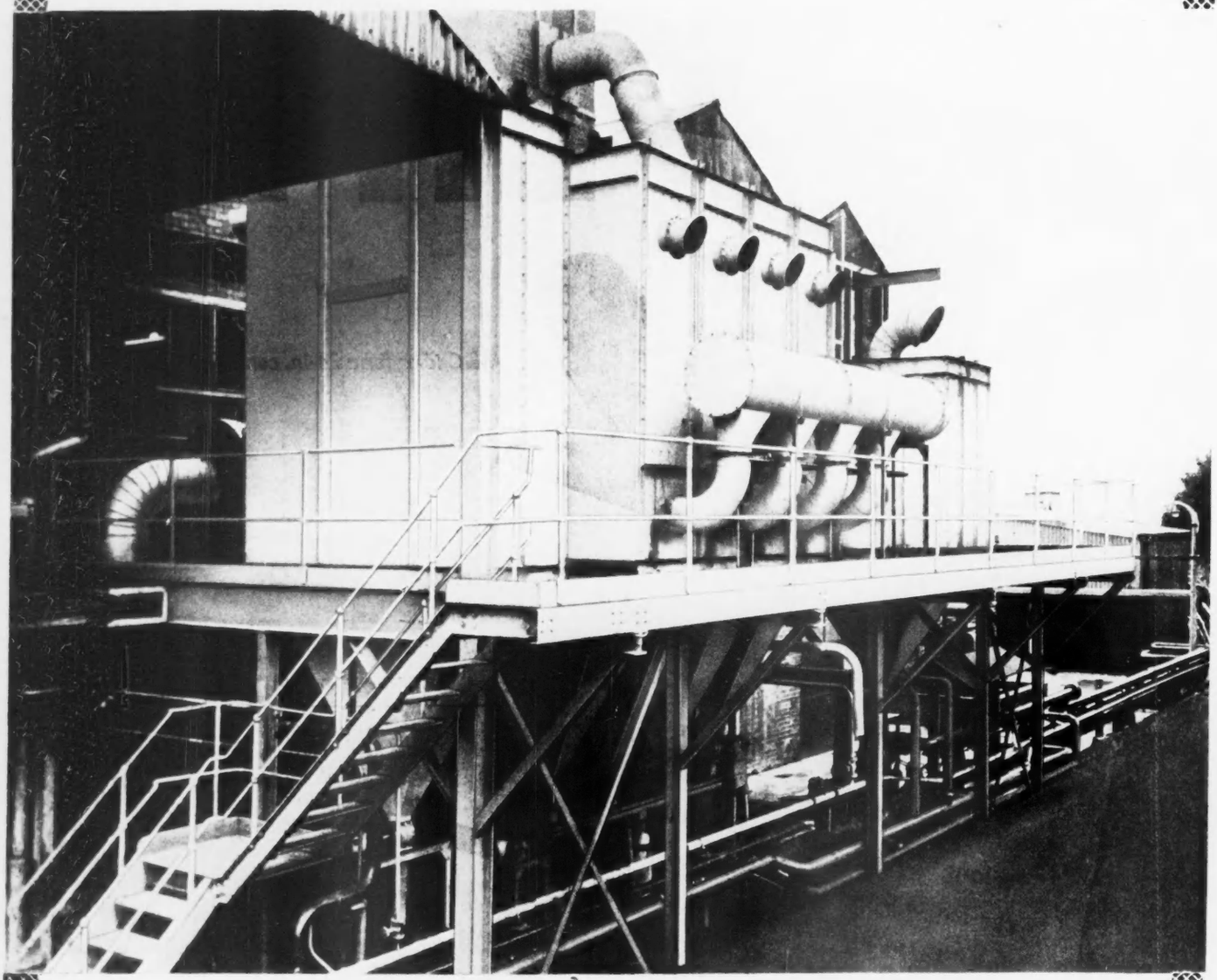

On the plant recently installed by Simon Handling Engineers, Ltd., for Imperial Chemical Industries, Ltd., Clitheroe, Tilghman automatic bag filters were chosen to remove and contain the very fine oxide powders from various mixing, pelletising and process handling points, etc.

The installation is shown in the photograph above. The collector in the centre is a 4-compartment model 126in. automatic bag filter. This handles the exhaust volume continuously and does not require shutting down for removal of accumulated dust from the filter tubes. The other two collectors are semi-automatic plants in which the filter tubes are automatically cleaned each time the exhaust fan is shut down.

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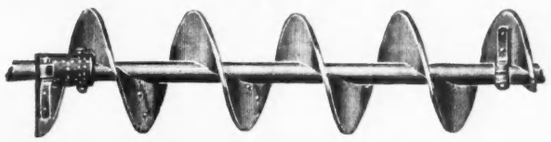

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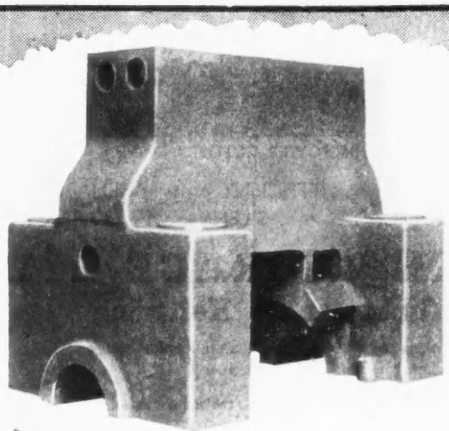

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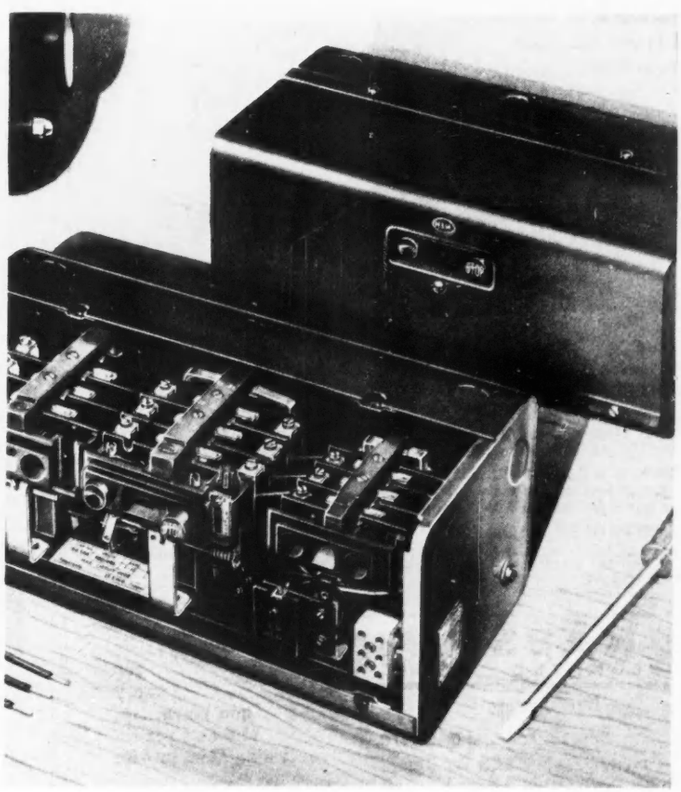

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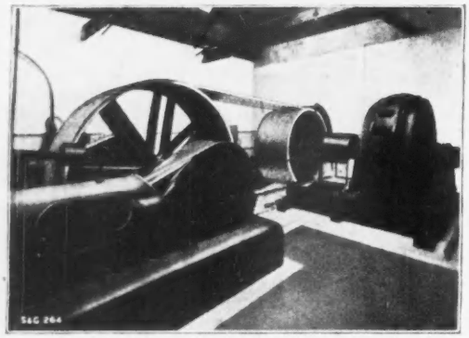

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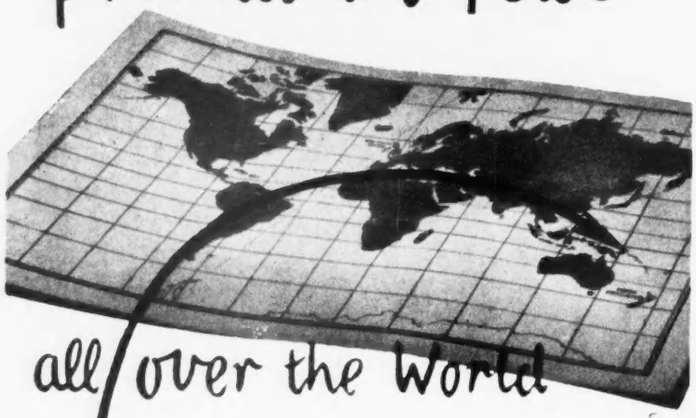
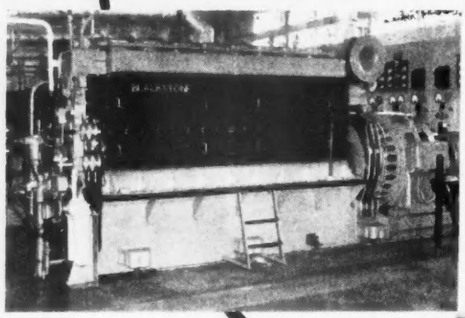


all over the world



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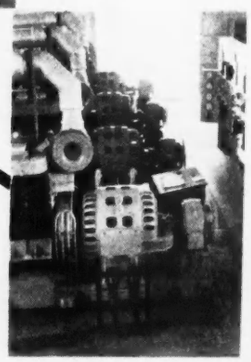
New Britain, electricity is supplied by four 320 kW alternators, each powered by a Lister Blackstone EVS8 480 h.p. diesel engine.



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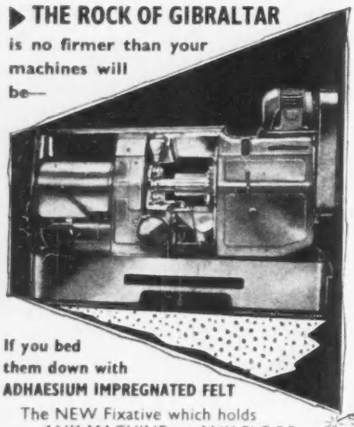

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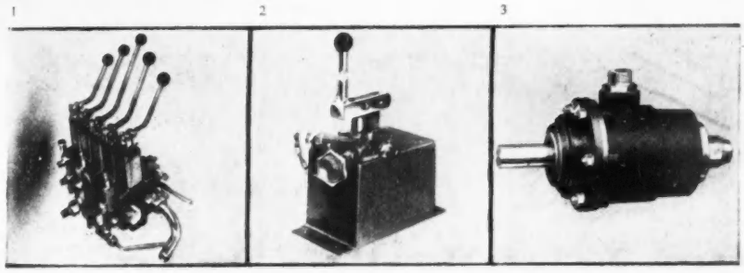

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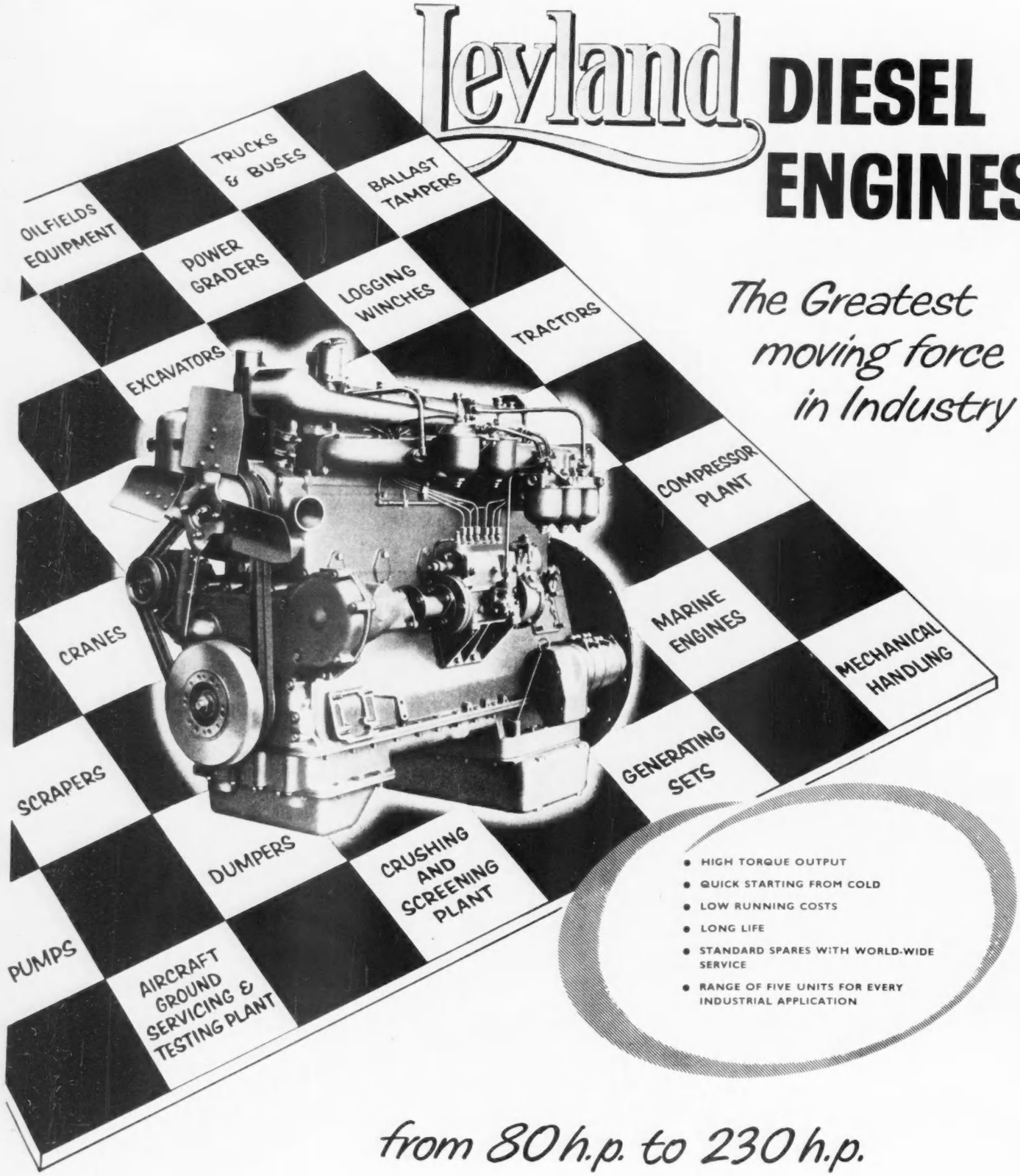

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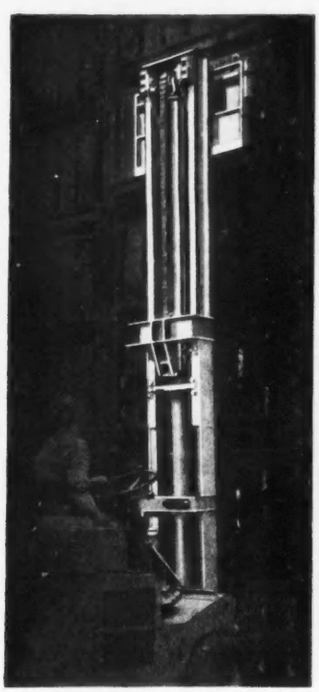
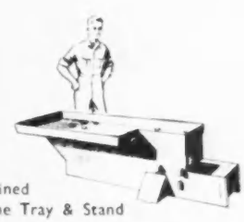


Mast Assembly for Fork Lift Truck



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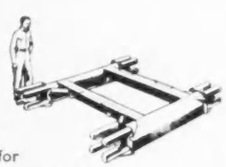
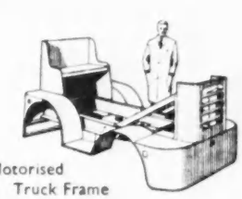
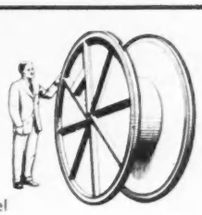


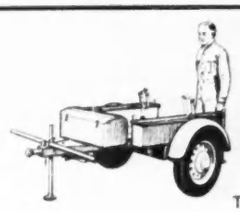
Chassis for Mechanical Digger



Motorised Truck Frame



Cable Reel



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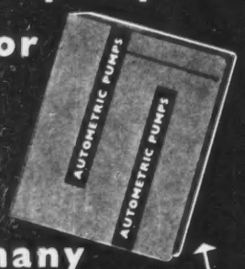

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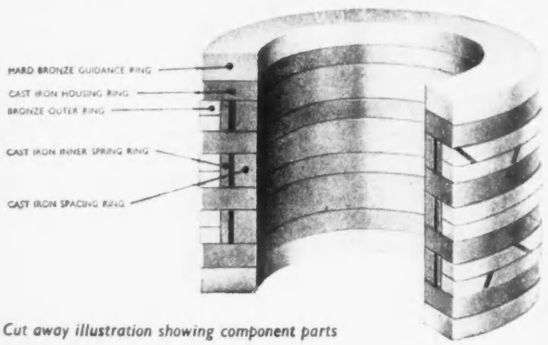

Cut away illustration showing component parts

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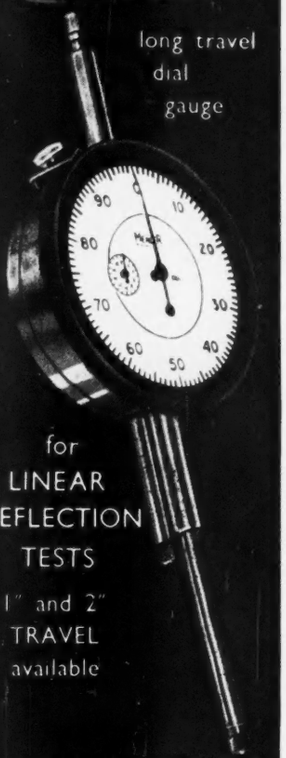

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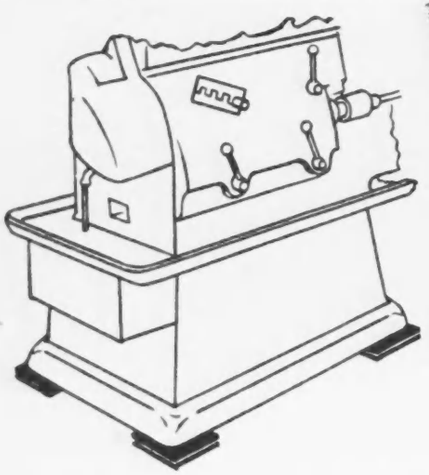

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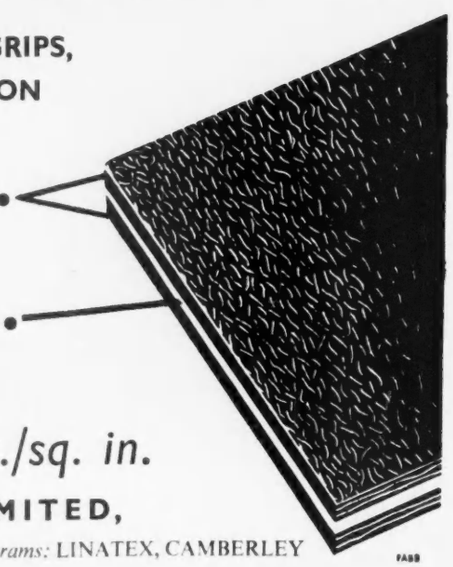

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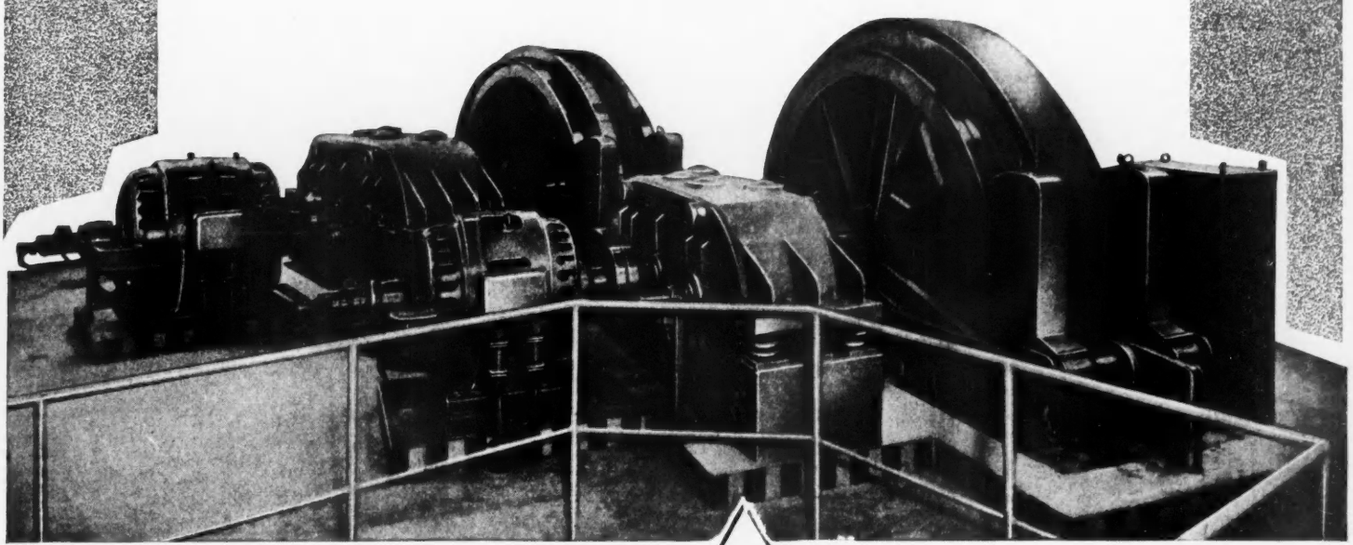

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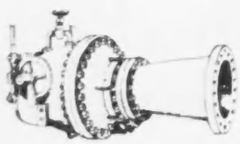
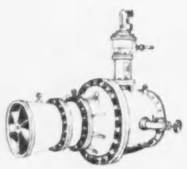
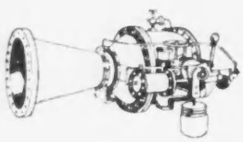


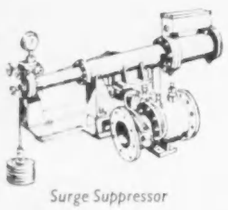
Pipeline Control Valve



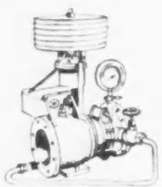
Discharge Regulator



Self Closing Valve

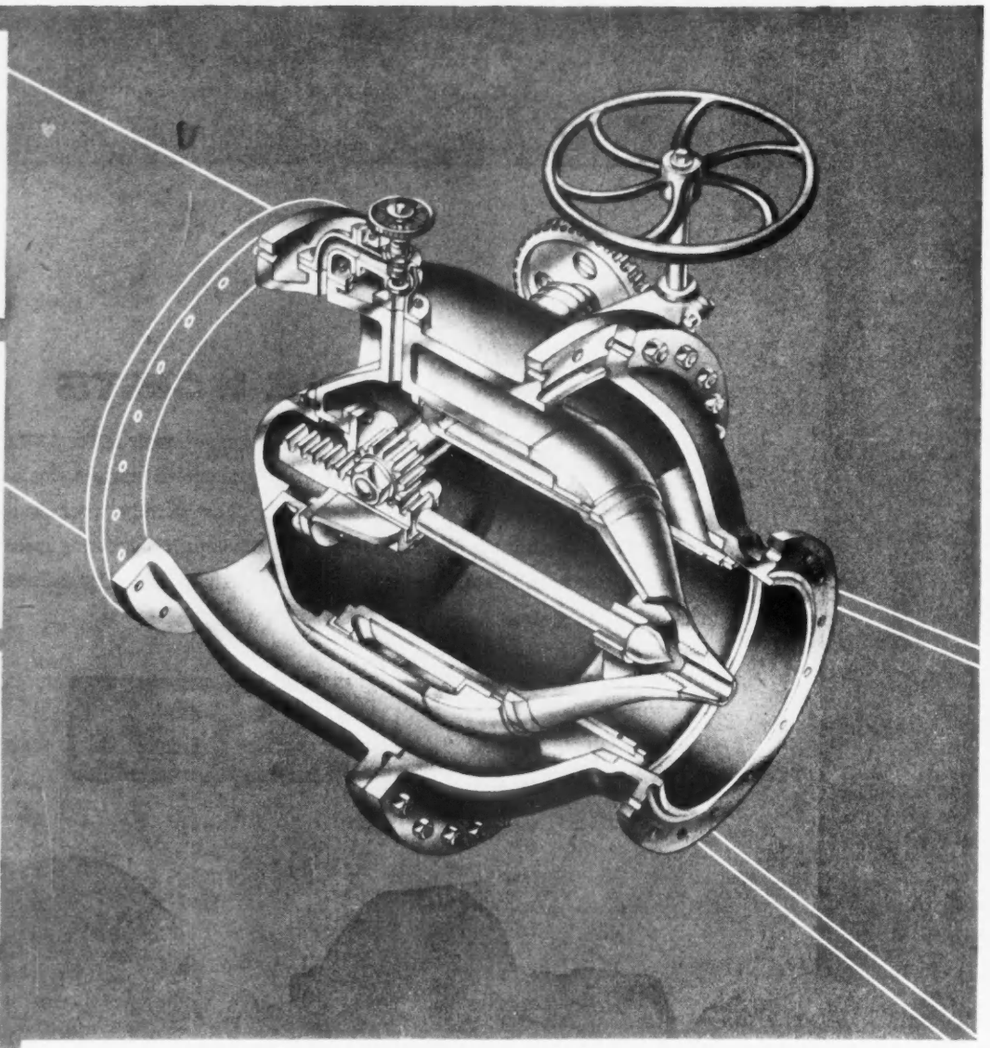


Surge Suppressor



Pressure Reducing Valve

Float Valve



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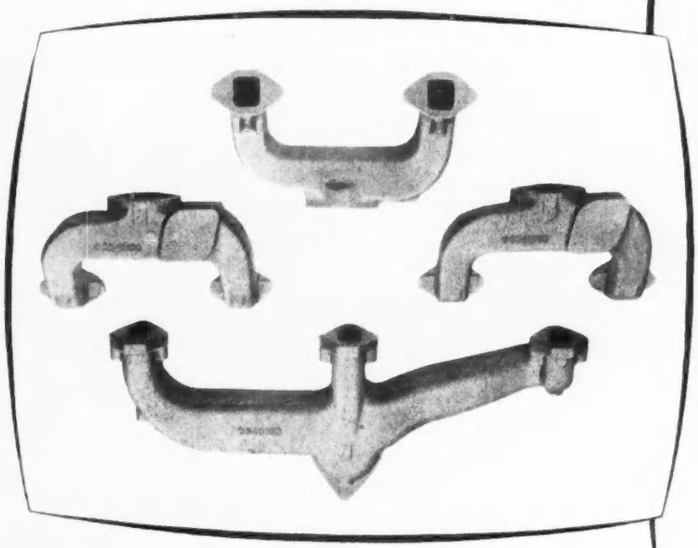

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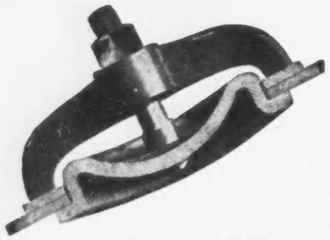

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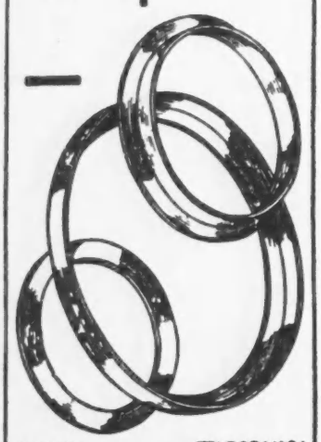

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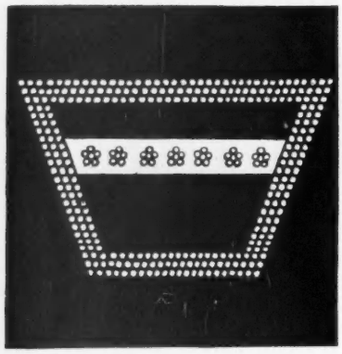

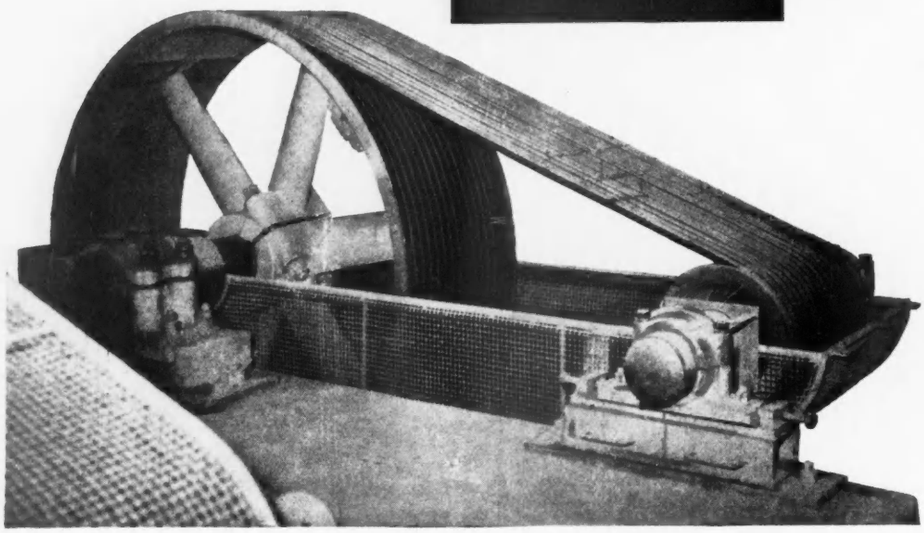

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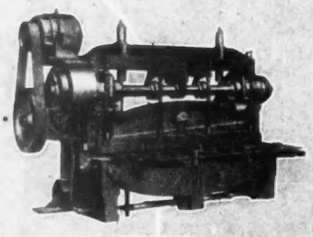

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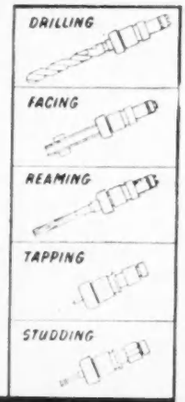

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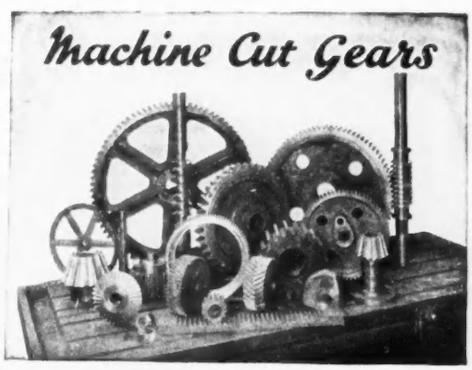

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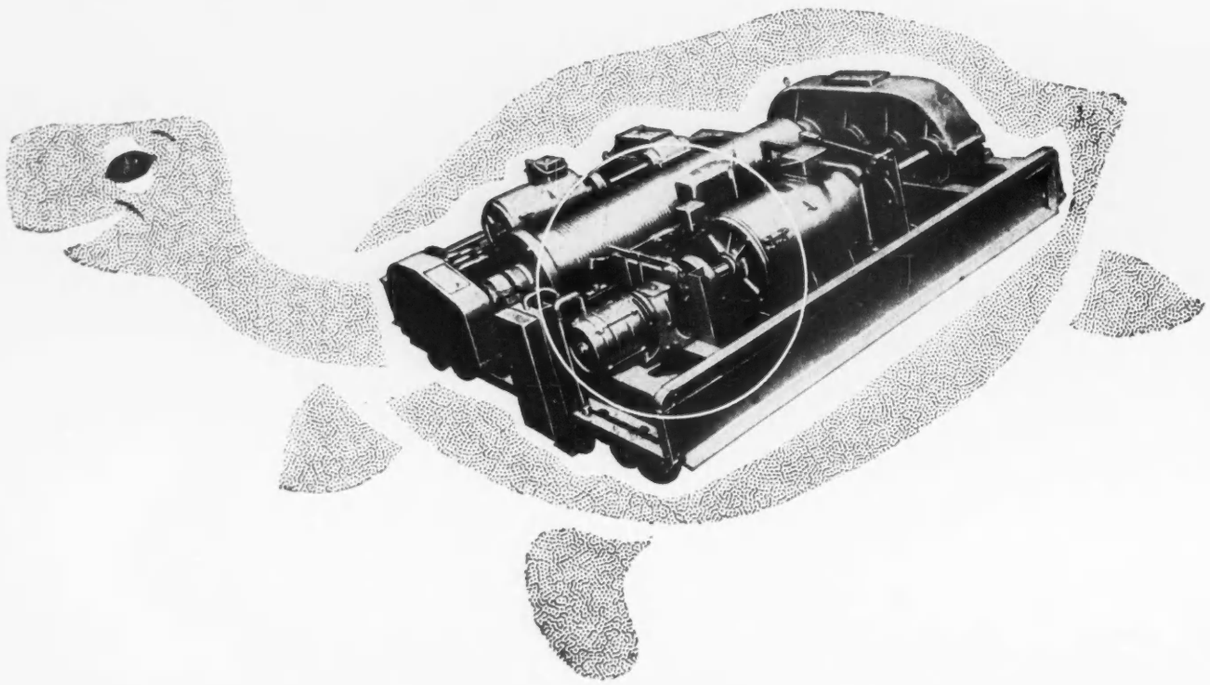

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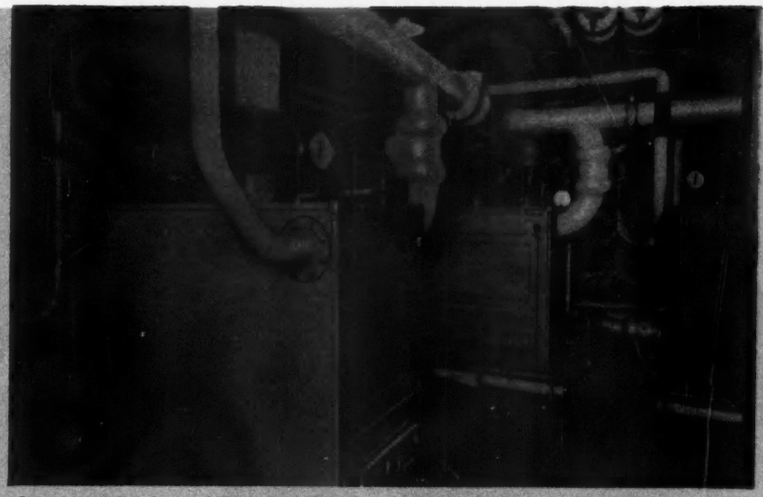

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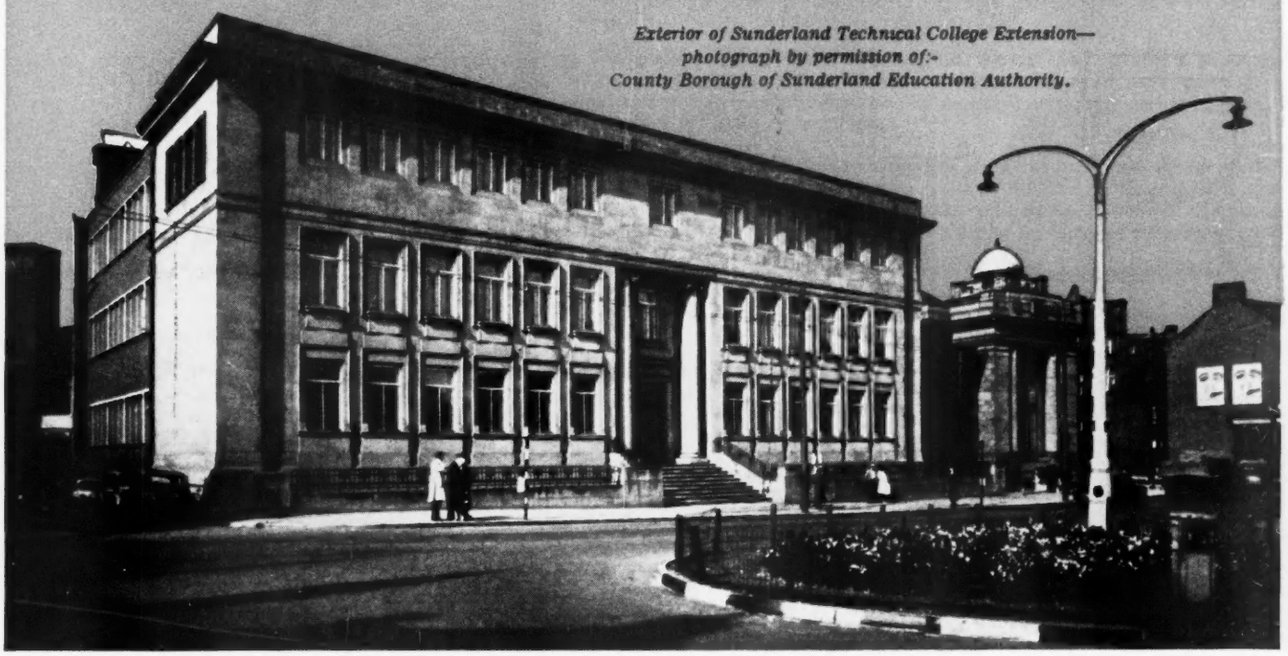

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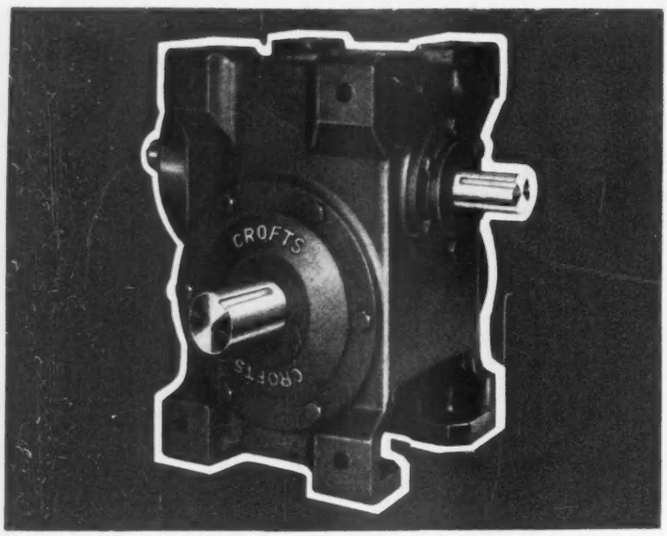

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A completely new range of Universal Worm Gear Units, with feet cast integrally with the case, developed to enable a single design to accommodate worm gears of the following types :

Standard (worm under wormwheel).
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This new **standardised** *design means these advantages :*

- *A common gearcase and components for the three types of worm gears, making possible* **up to 50 mounting positions and different arrangements of input and output shafts.**
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- *Quickly and easily modified from one assembly to another, by either customer or stockists, by the simple interchange of oil fillers, drain and level plug positions only.* **No expensive stripping and fitting required.**
- **Interchangeable with essential dimensions of British Standards 3027 : 1958 Specifications of Dimensions for Worm Gear Units, sizes 4in., 6in. and 8in. centres.** *(Worm under wormwheel type. See diagram.)*
- *The double extension wormshaft makes either right or left-hand assembly possible by simply removing the fan and cowl and replacing them on the opposite end.*

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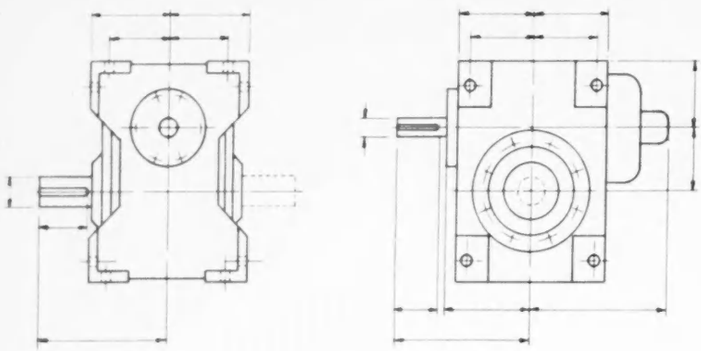

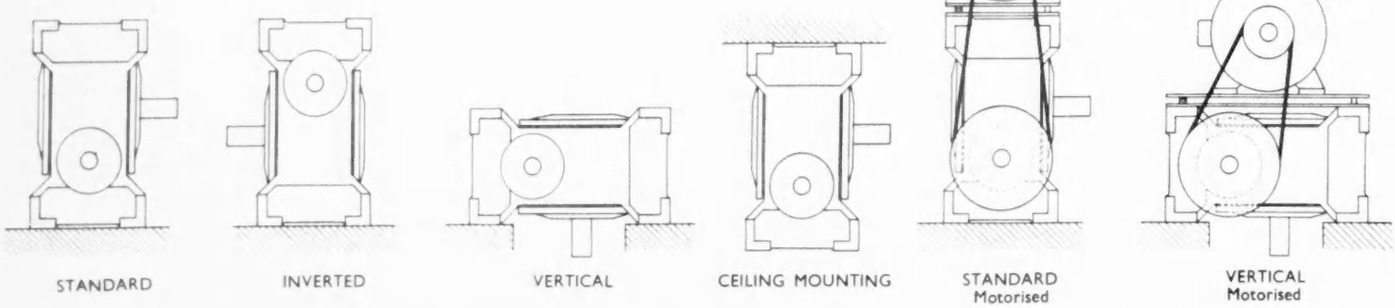

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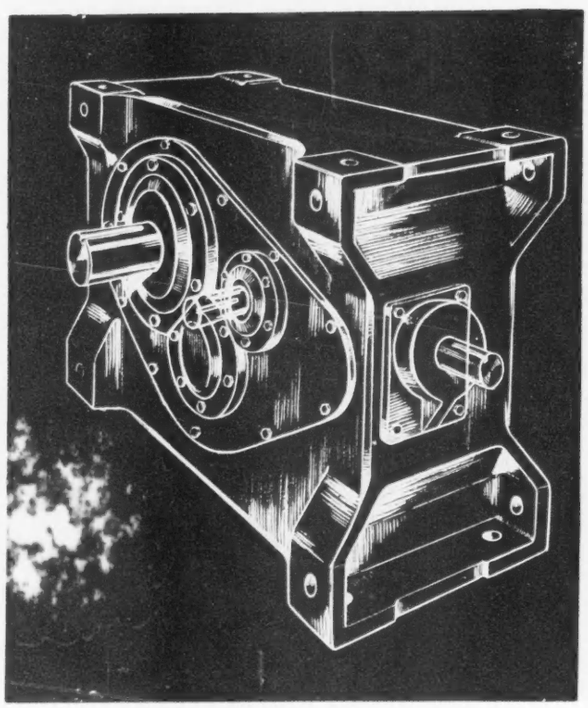

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- *Adaptable to any installation.*
- *In any mounting position.*
- *For any combination of gears or shaft arrangement.*
- *Available in a wide range of ratios.*
- *Up to* 500 *horsepower.* (*Smaller units available with flange-mounted motors.*)

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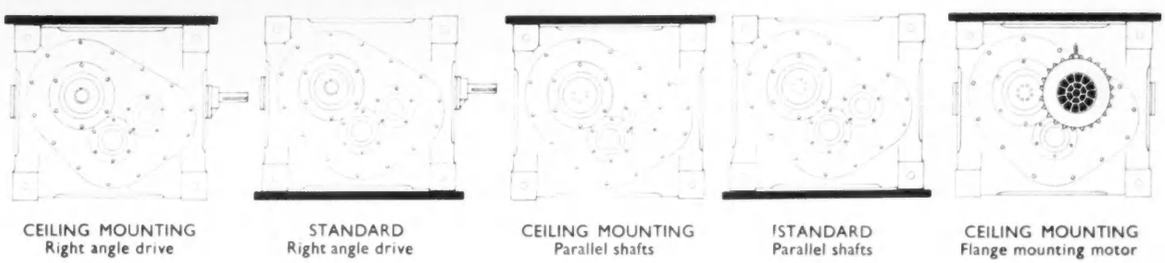
The gears are single helical throughout, standardised to give a wide range of ratios, with single, double or triple reduction gear trains as required, and with parallel input and output shaft dispositions—or available as right angle drives using spiral bevel gears for the first reduction.

Regardless of the size or combination of gears, the input and output shafts are in the same horizontal plane, and for each size of unit are dimensionally in the same disposition to each other, whether supplied with single, double or triple reduction gear trains, or arranged as parallel shaft units or as right angle drives.



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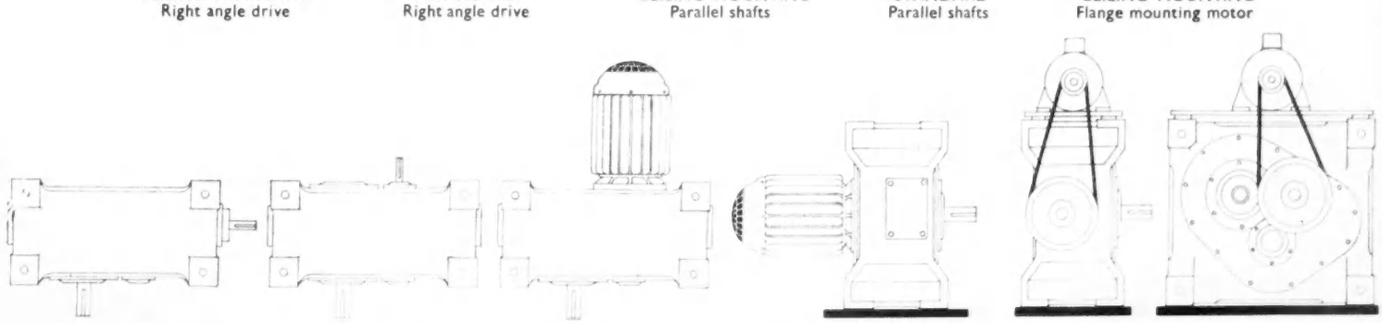

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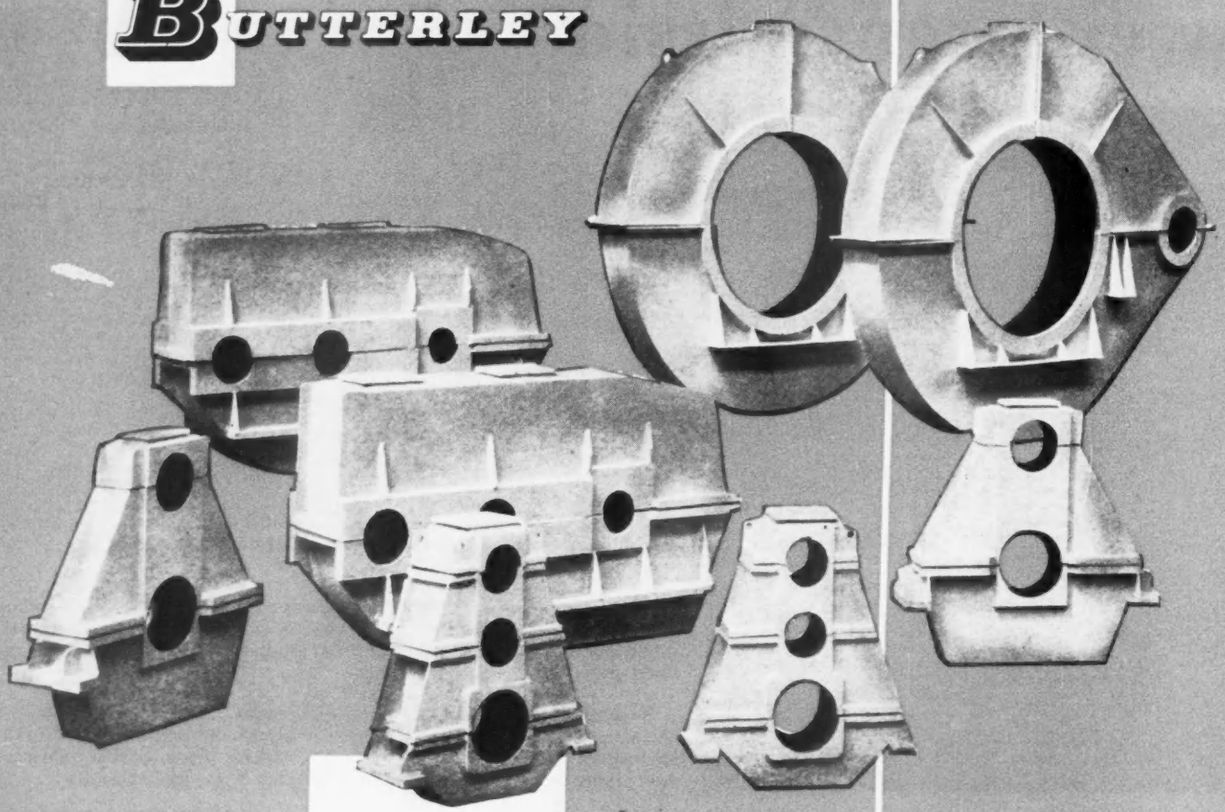

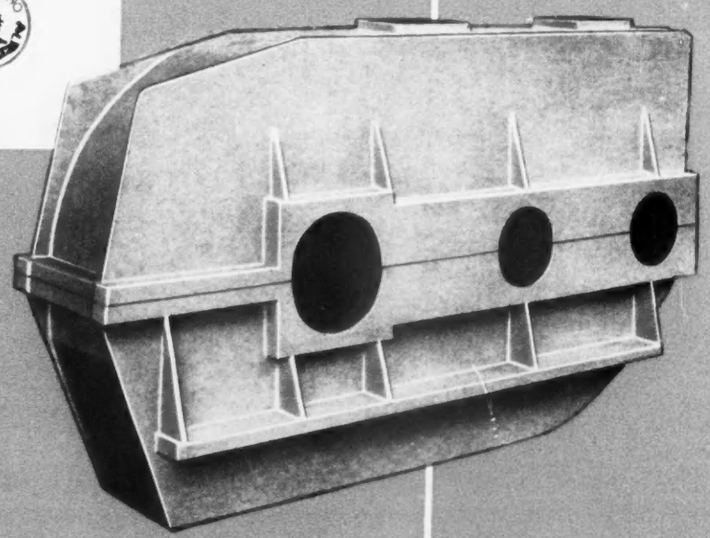

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WP2A

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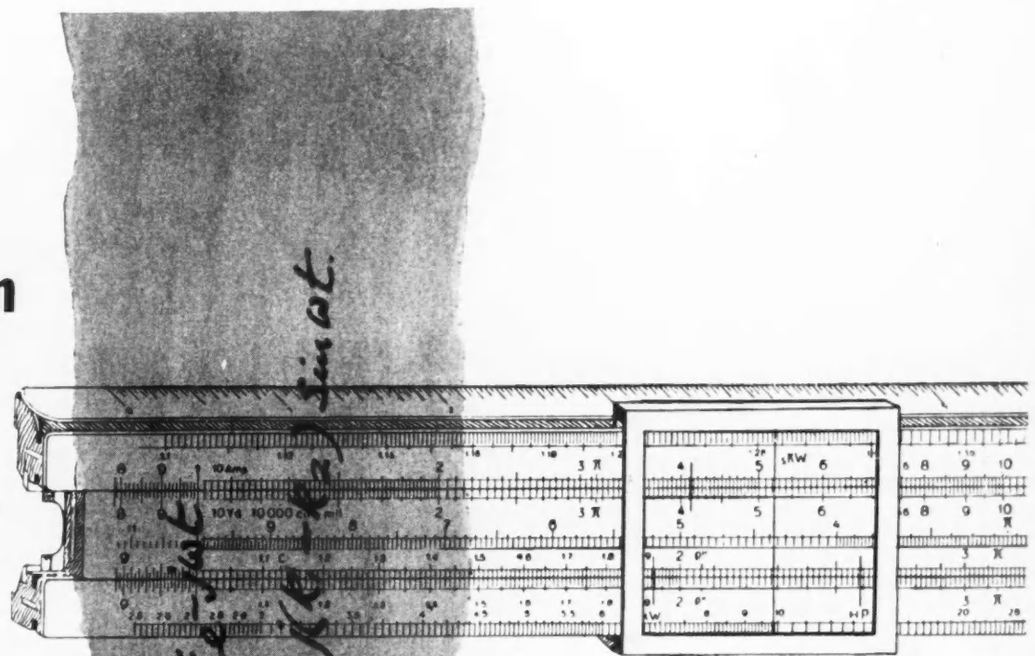

You may start a design with figures on paper, but all that it can give you is a set of dimensions. To turn these into something that can be made needs a lot more work at a drawing board and in the shops. This part of design cannot be written down; it depends on a different kind of knowledge, on a feeling for materials, a trained eye. In a word, on experience.

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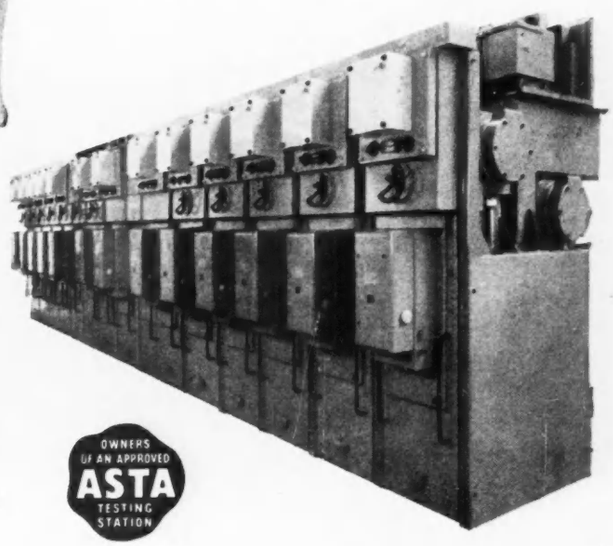

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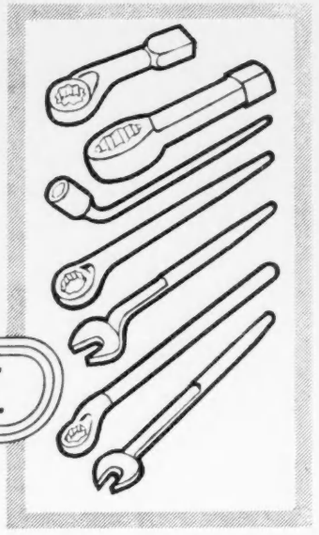

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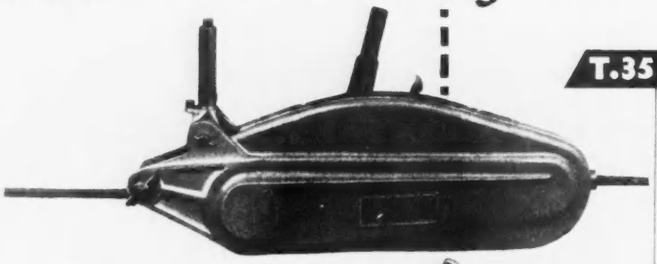
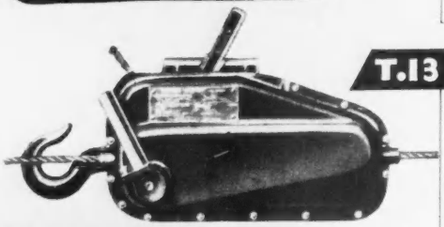


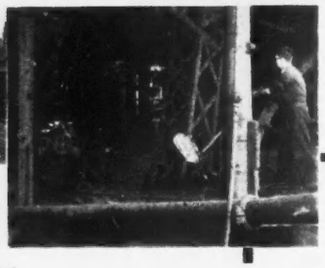
T.35

CAPACITY	LIFTING (SWL) 3 TONS PULLING 5 TONS
EFFORT	70 120 LBS.
WEIGHT	59 LBS.
SPEED	3/9 FT. PER MIN
SIZE	28½" x 12½" x 5½"
MECH. ADV.	85 : 1



T.13

CAPACITY	LIFTING (SWL) 1 TON PULLING 30 CWT.
EFFORT	77 LBS.
WEIGHT	39 LBS.
SPEED	11½ FT. PER MIN
SIZE	24" x 12" x 6"
MECH. ADV.	43 : 1



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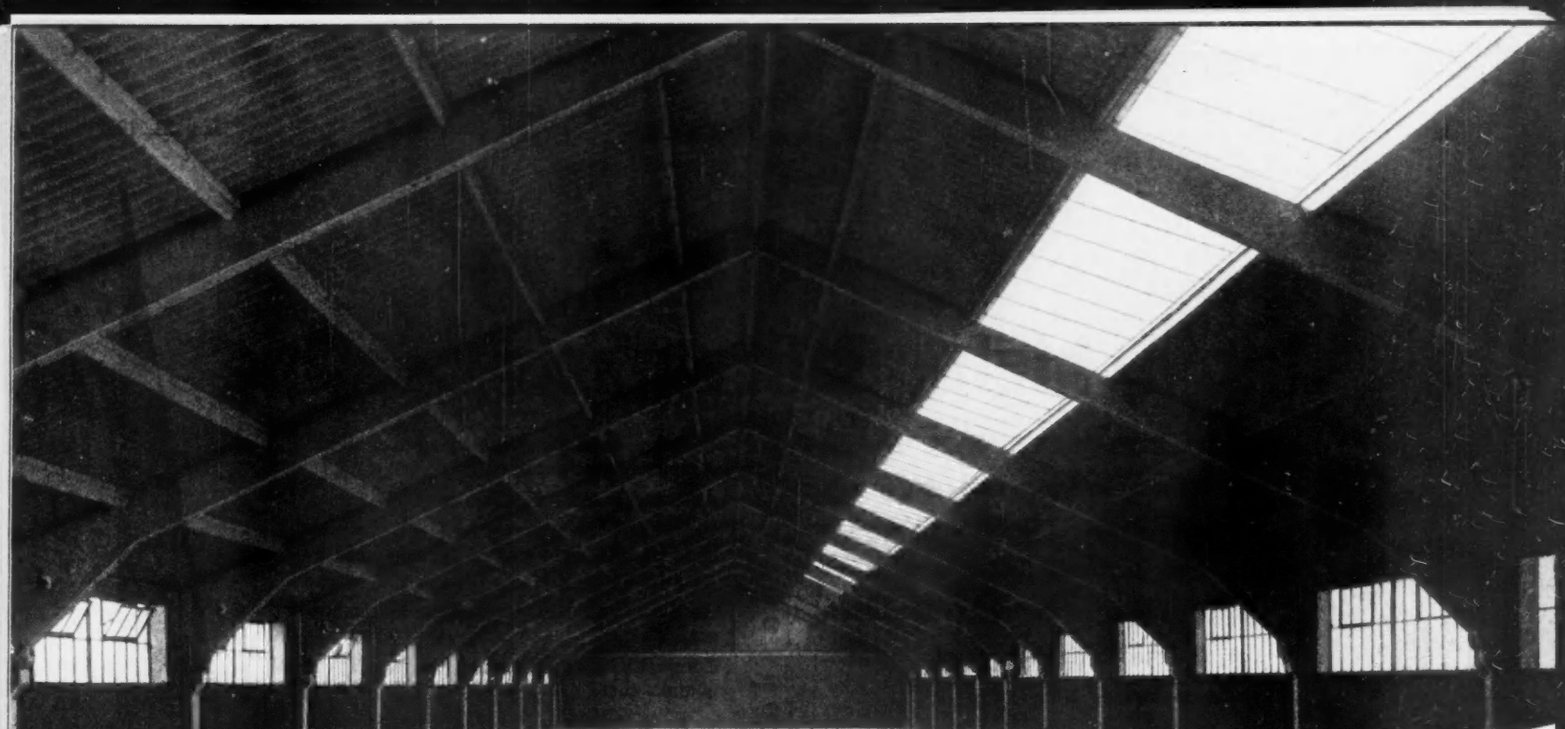

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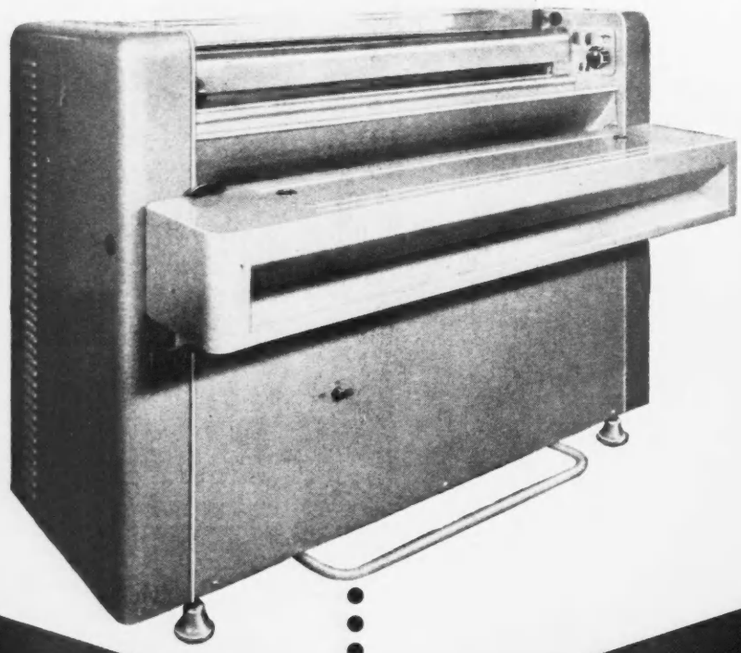

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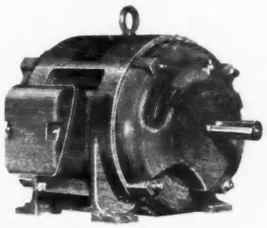

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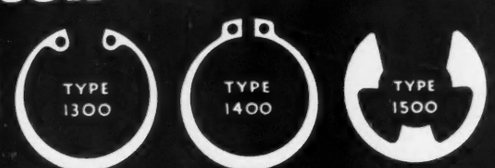

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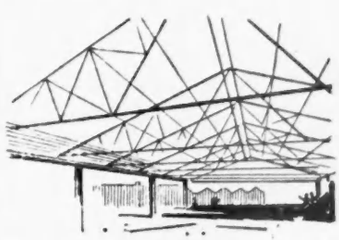

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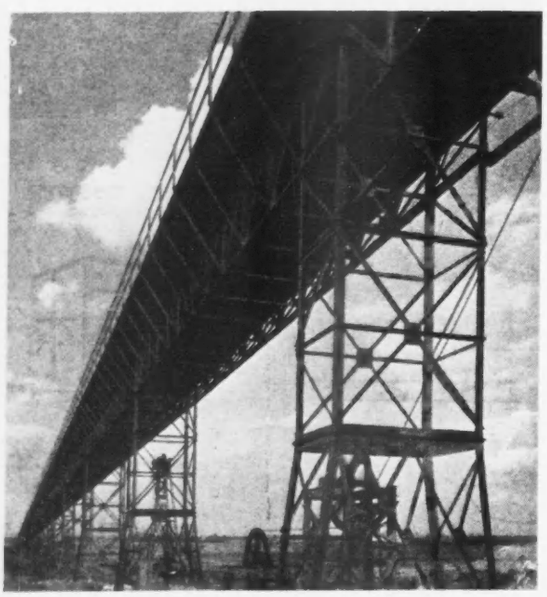

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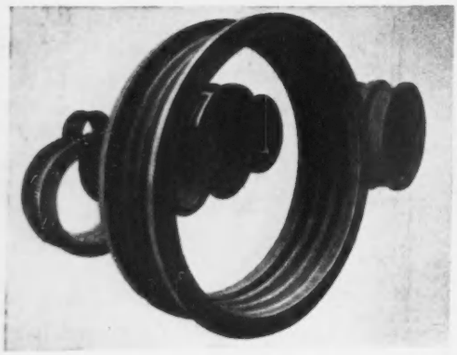

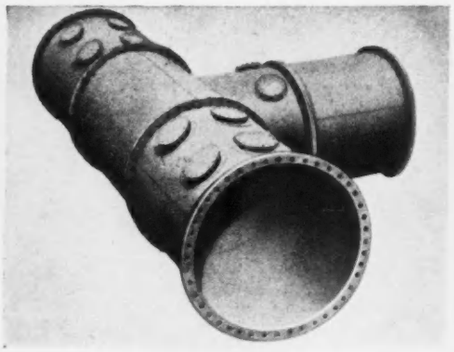

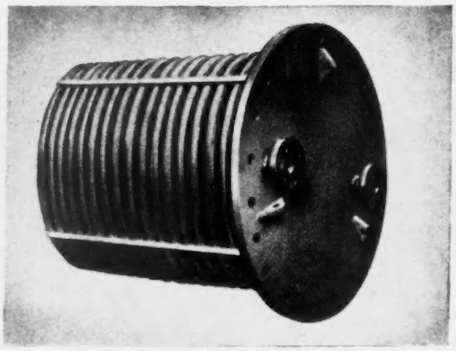

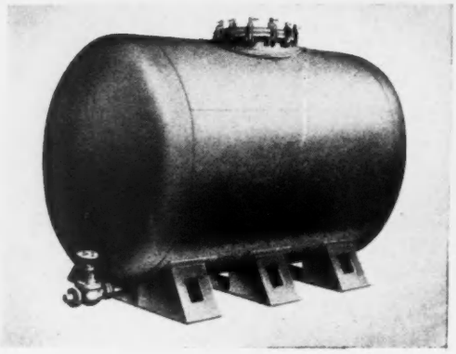

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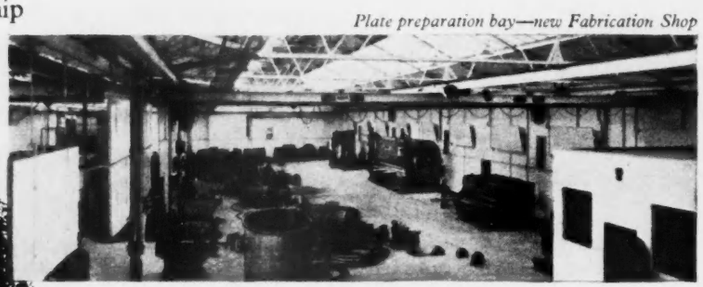

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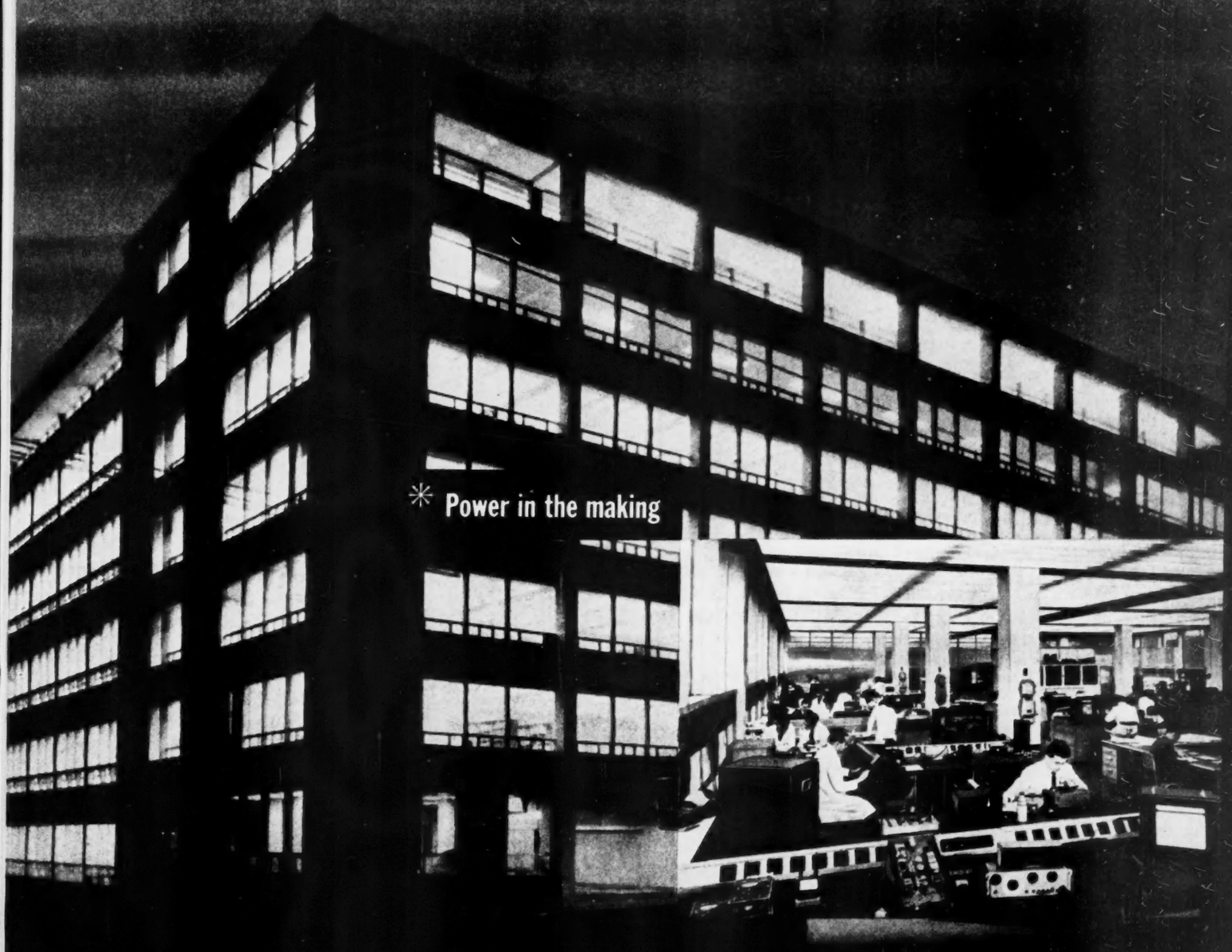

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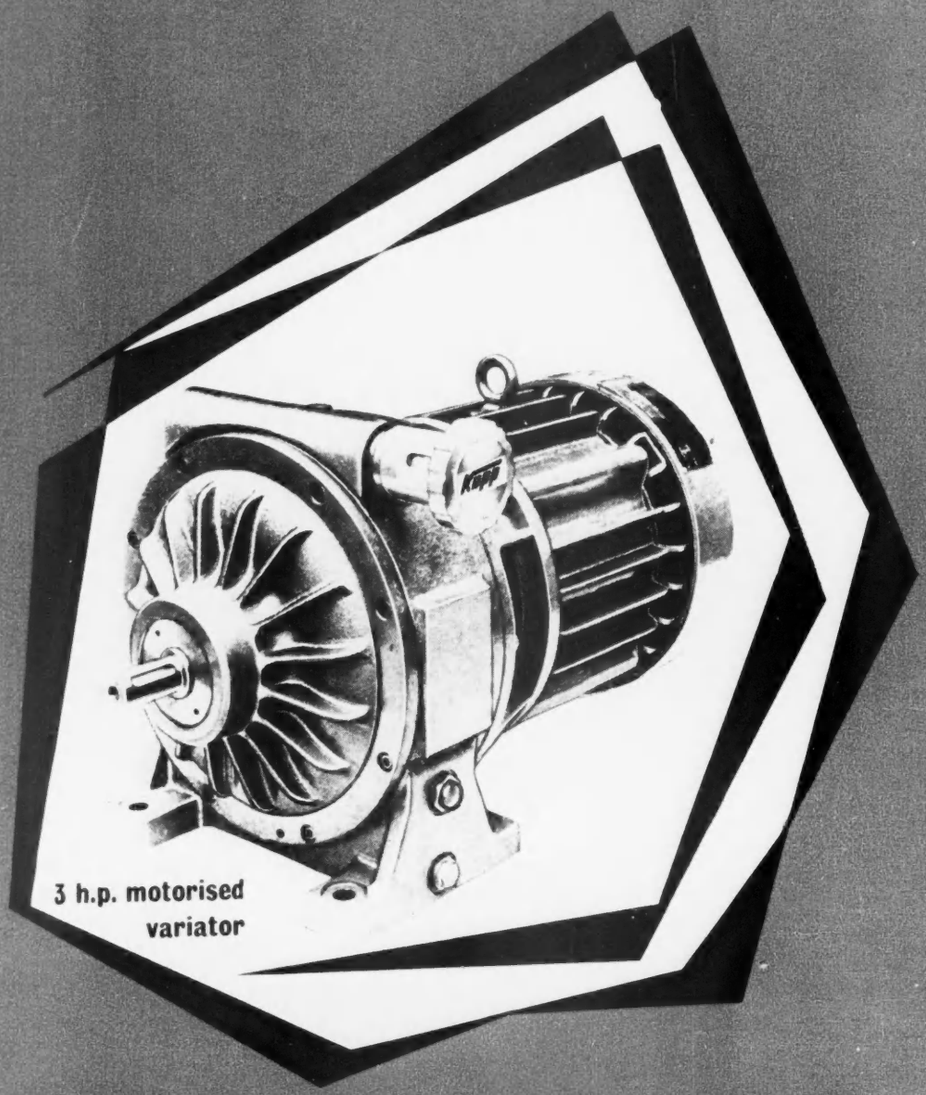

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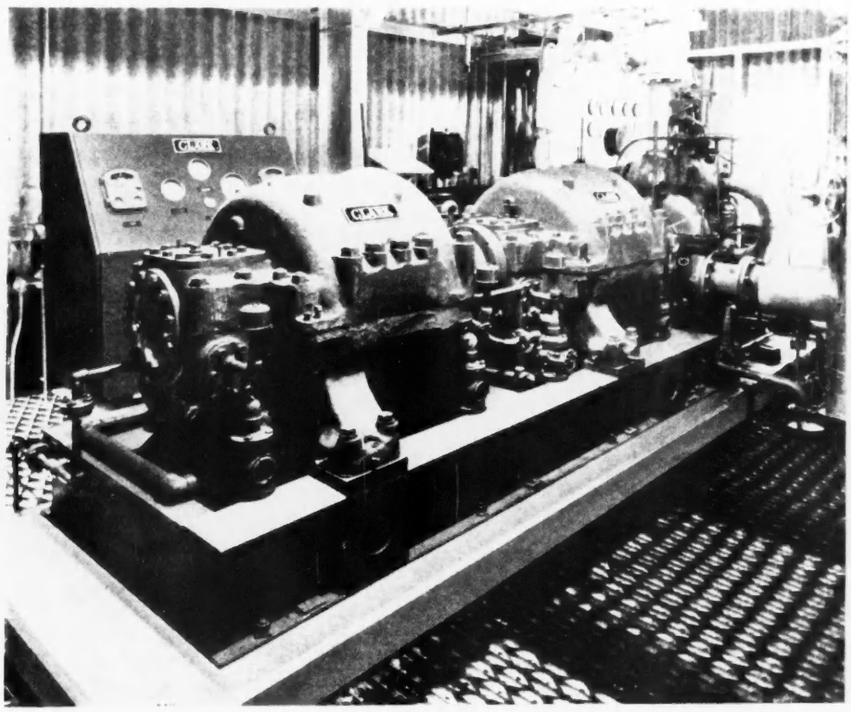

Three Clark No. 2 case 3 impeller centrifugal compressors for process gas on butene dehydrogenation duty at modern refinery of Esso Petroleum Company Limited, Fawley. Low stage 2650 S.C.F.M. High stage 2300 S.C.F.M. 9000 rpm. 1820 bhp. Driven by direct coupled steam turbine.

How Clark Centrifugals serve at Fawley

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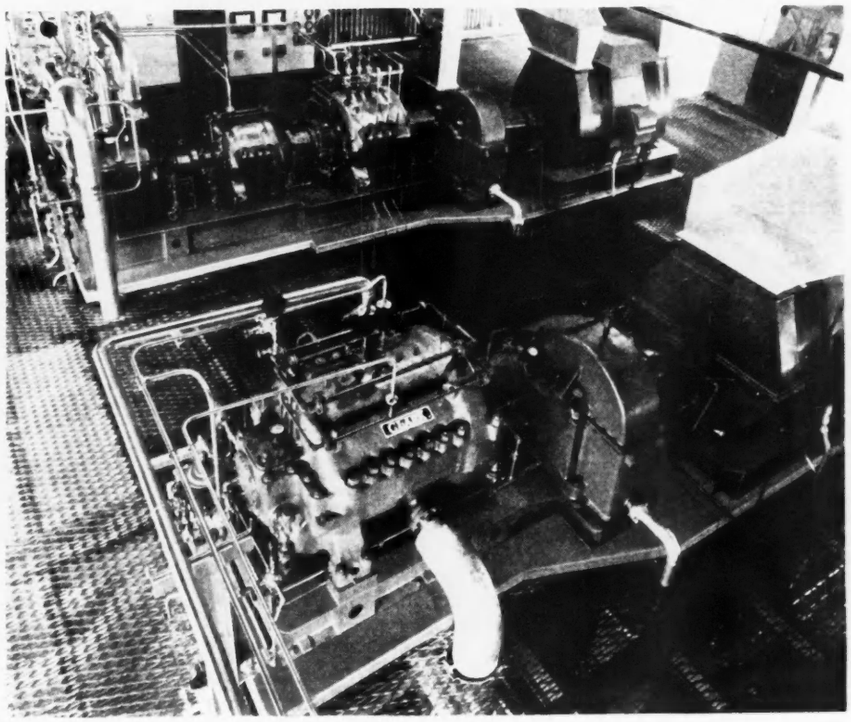

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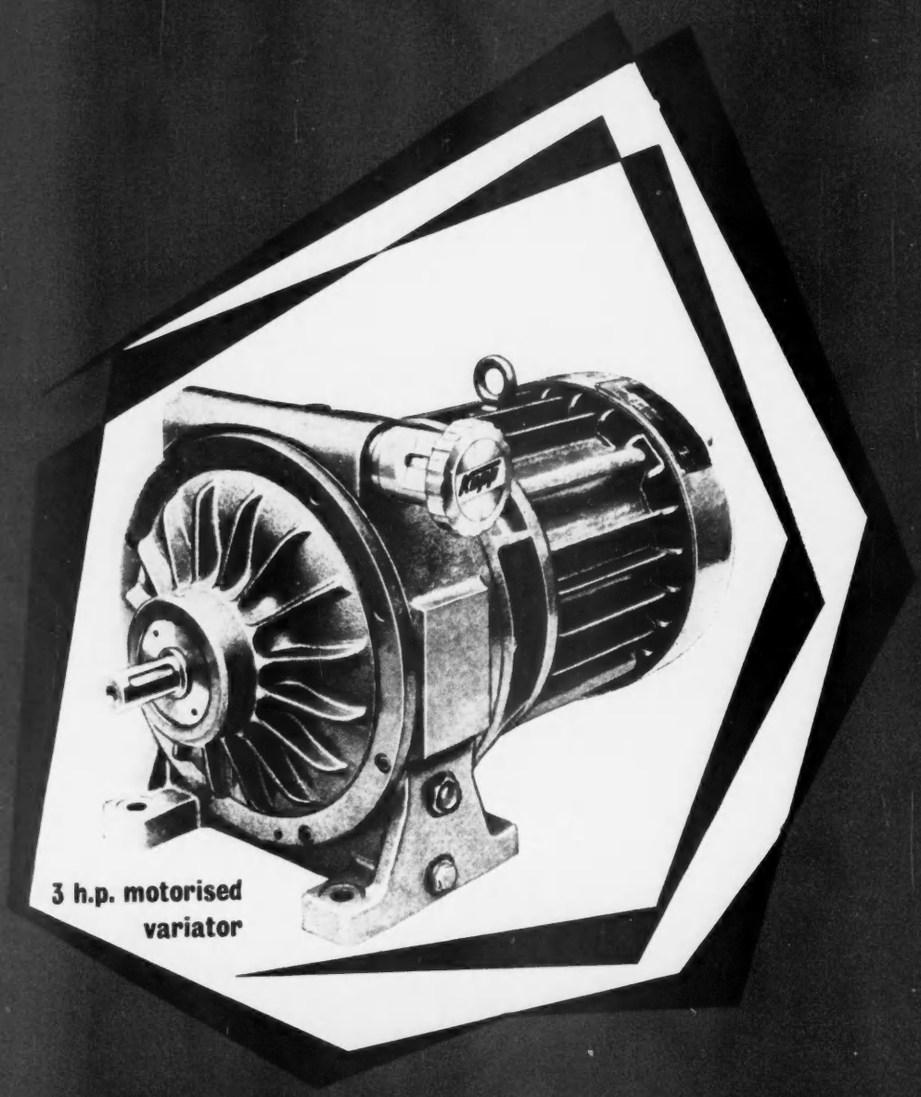
Three Clark centrifugal compressors at Esso refinery at Fawley. Driven in tandem through speed increaser gear by 3500 bhp electric motor. 1st stage No. 3 case 4 impeller 11,400 S.C.F.M. at 8450 rpm. 2nd stage No. 2 case 5 impeller 5960 S.C.F.M. 3rd stage No. 1 case 7850 S.C.F.M. and

Clark No. 3 case 7 impeller centrifugal compressor equipped with pneumatically controlled variable inlet guide for propylene refrigeration duty on ethylene recovery. 1315 lbs/min. at suction temperature of —30F. with one outlet and two inlet sidestreams. Driven at 6700 rpm. through speed increaser gear by 2500 bhp. electric motor.



3 h.p. motorised variator

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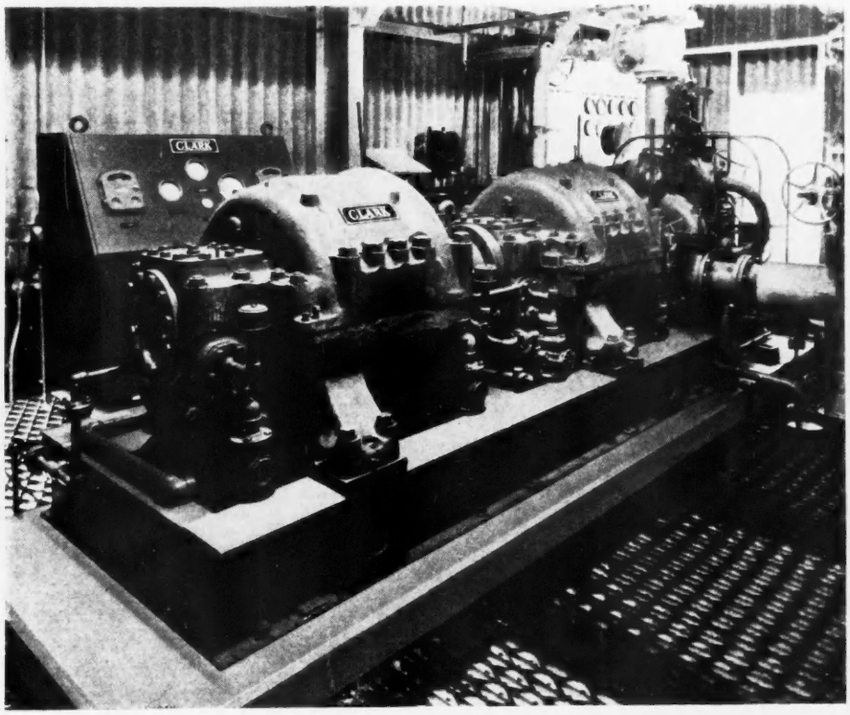

Two Clark No. 2 case 4-impeller centrifugal compressors for process gas on butene dehydrogenation duty at modern refinery of Esso Petroleum Company Limited, Fawley. Low stage 7650 S.C.F.M. High stage 7300 S.C.F.M. 9000 rpm., 1820 bhp. Driven by direct coupled steam turbine.

How Clark Centrifugals serve Esso at Fawley

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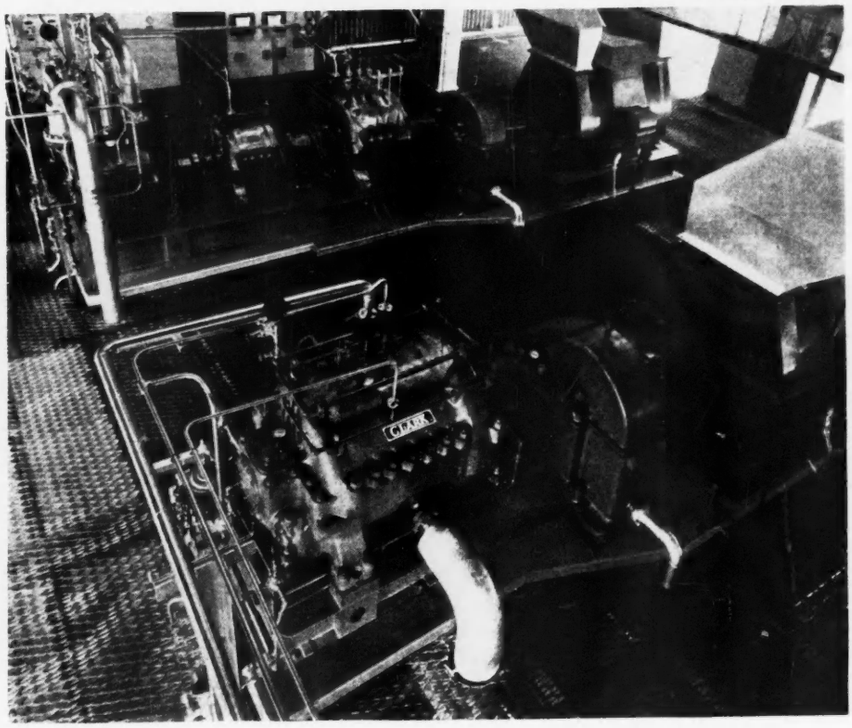

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Three Clark centrifugal compressors at Esso refinery at Fawley. Driven in tandem through speed increaser gear by 3500 bhp electric motor: 1st stage, No. 3 case 4-impeller 11,400 S.C.F.M. at 8450 rpm.; 2nd stage, No. 2 case 5-impeller 8960 S.C.F.M.; 3rd stage, No. 1 case 7850 S.C.F.M. and

Clark No. 3 case, 7-impeller centrifugal compressor equipped with pneumatically controlled variable inlet guide for propylene refrigeration duty on ethylene recovery. 1315 lbs./min. at suction temperature of −40F°, with one outlet and two inlet sidestreams. Driven at 6700 rpm. through speed increaser gear by 3500 bhp. electric motor.

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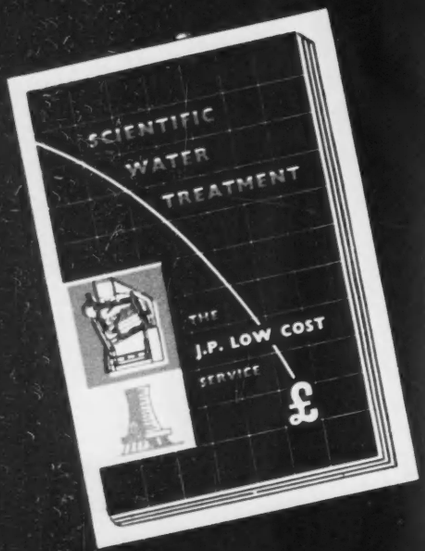

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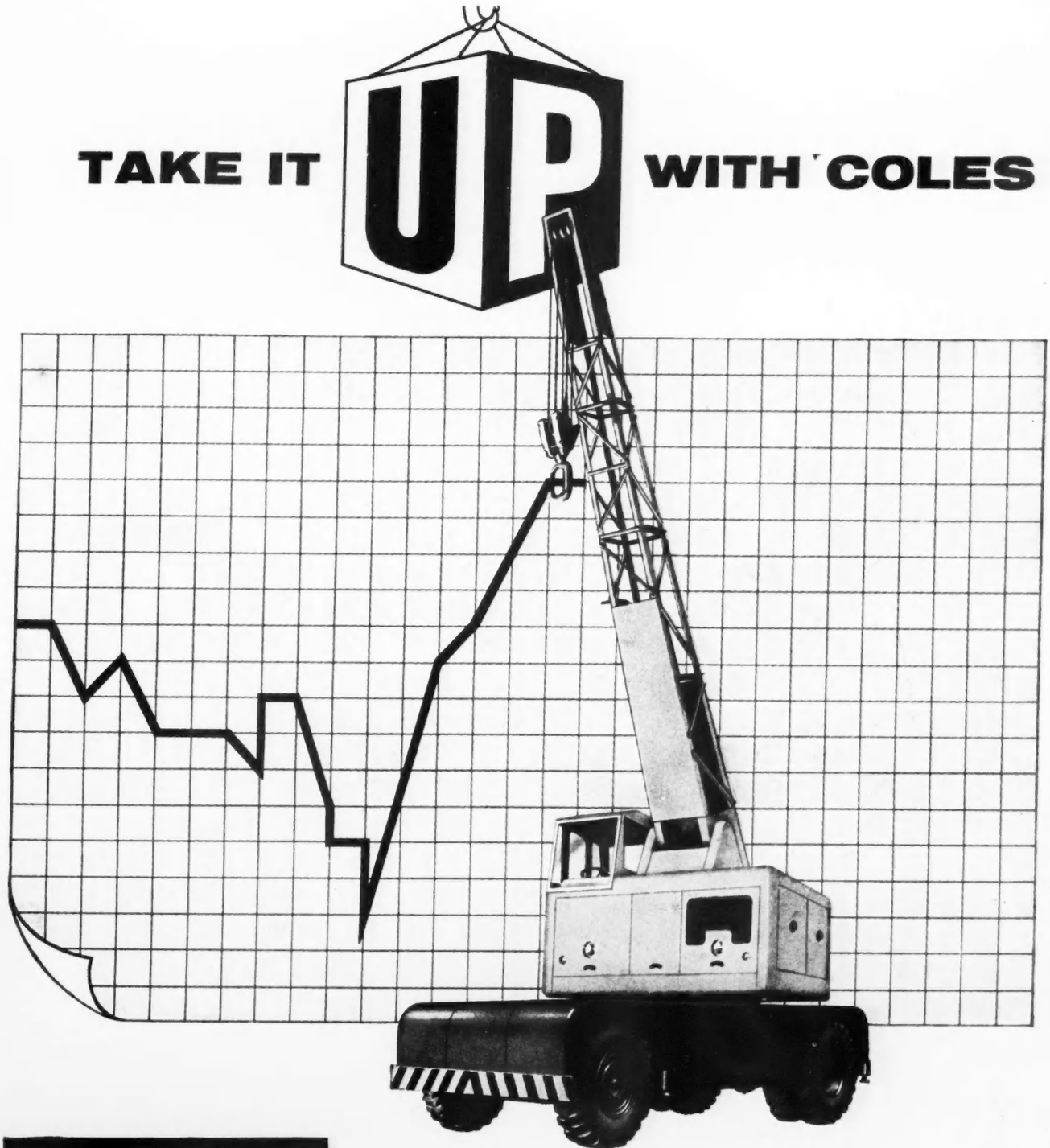

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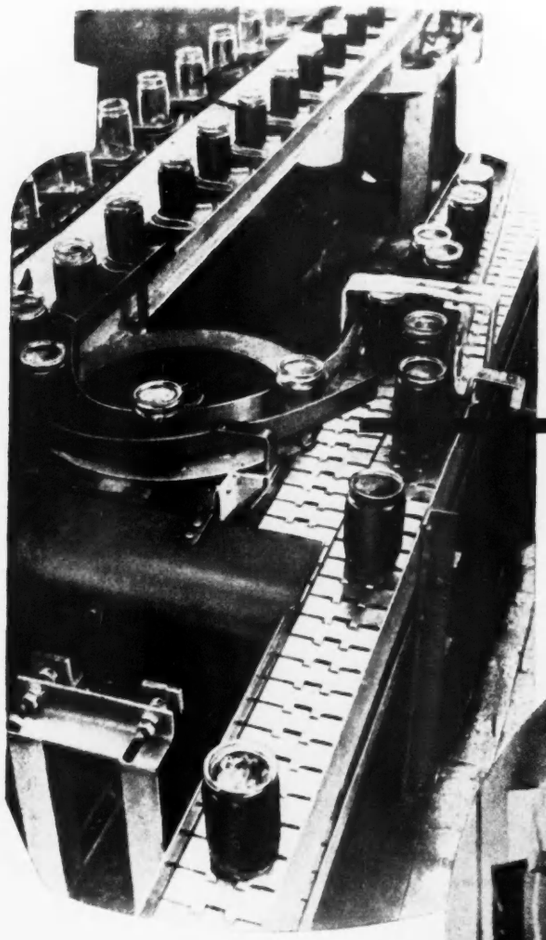

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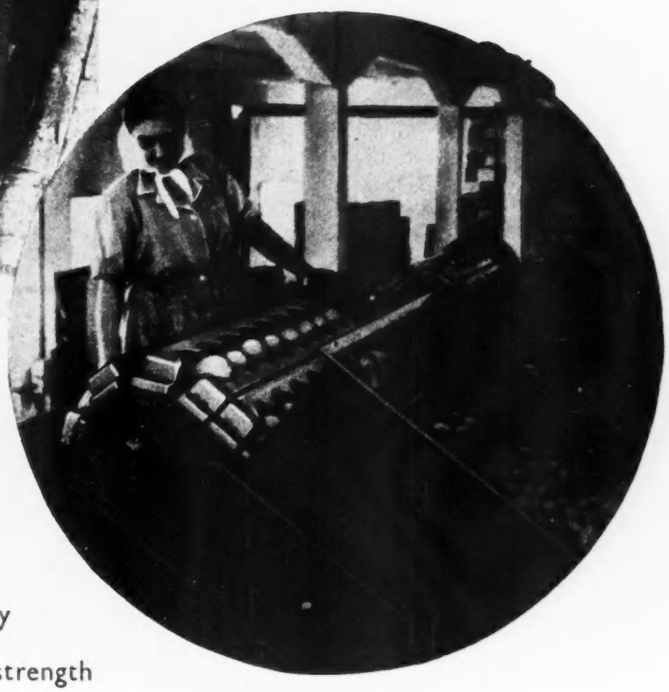

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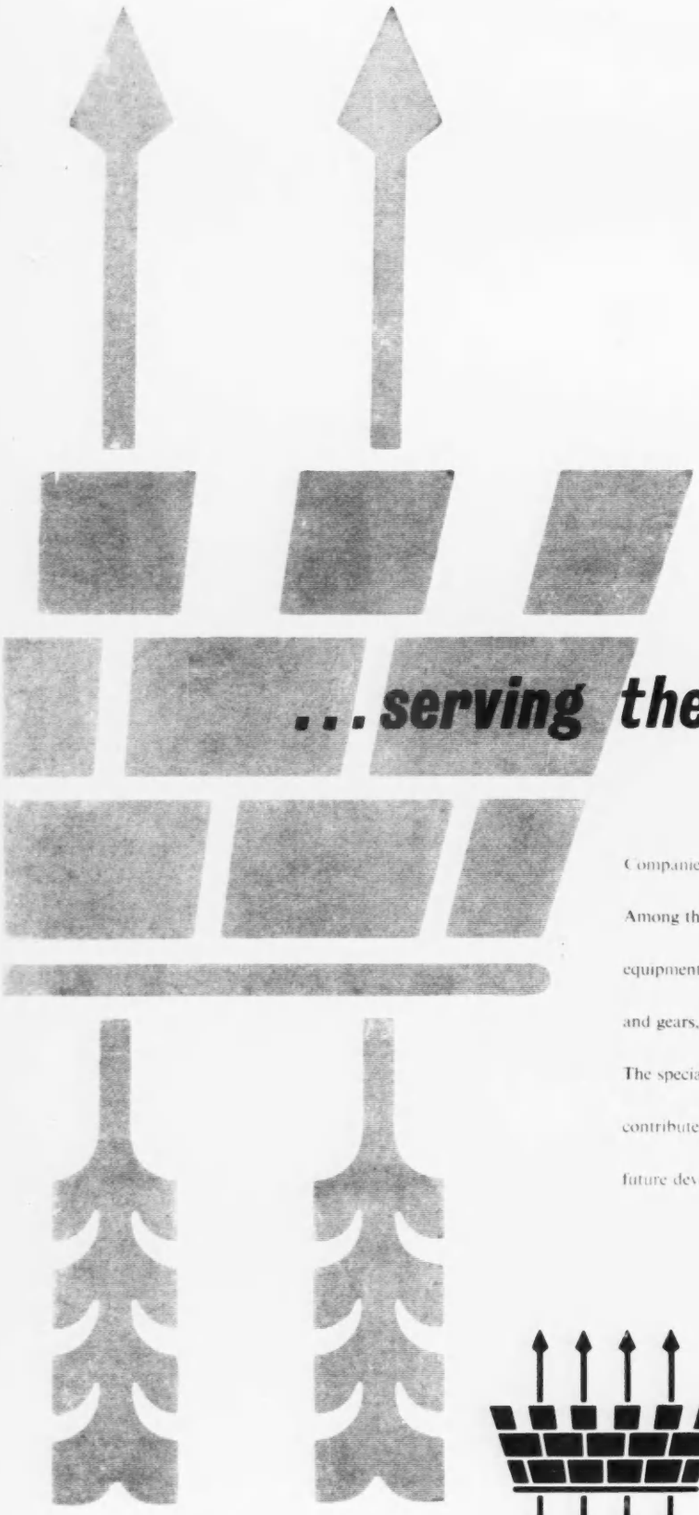

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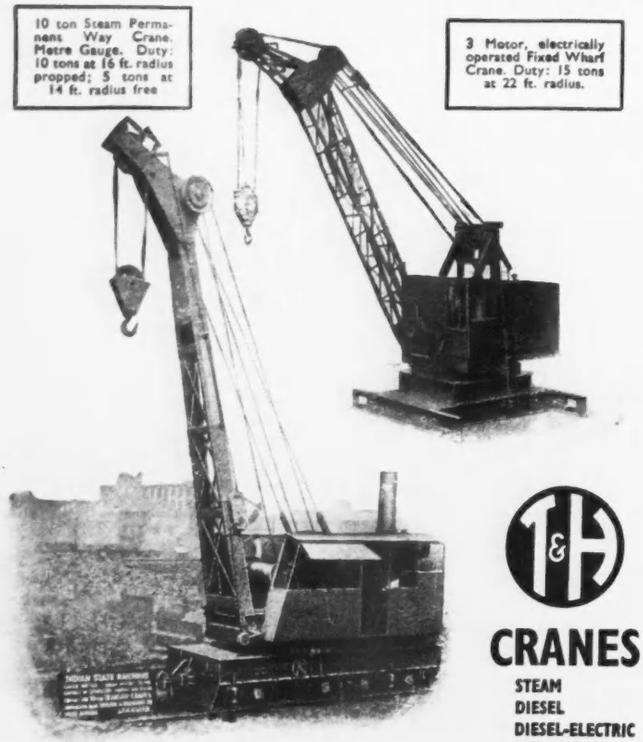

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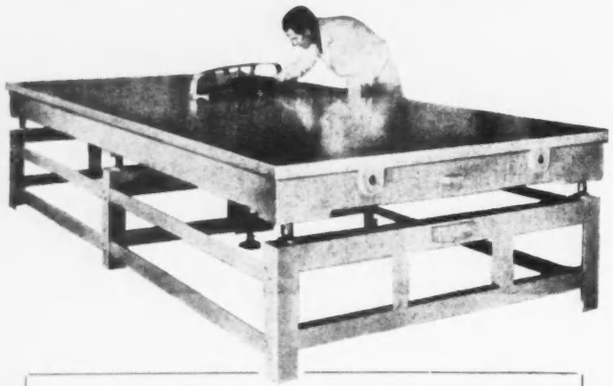

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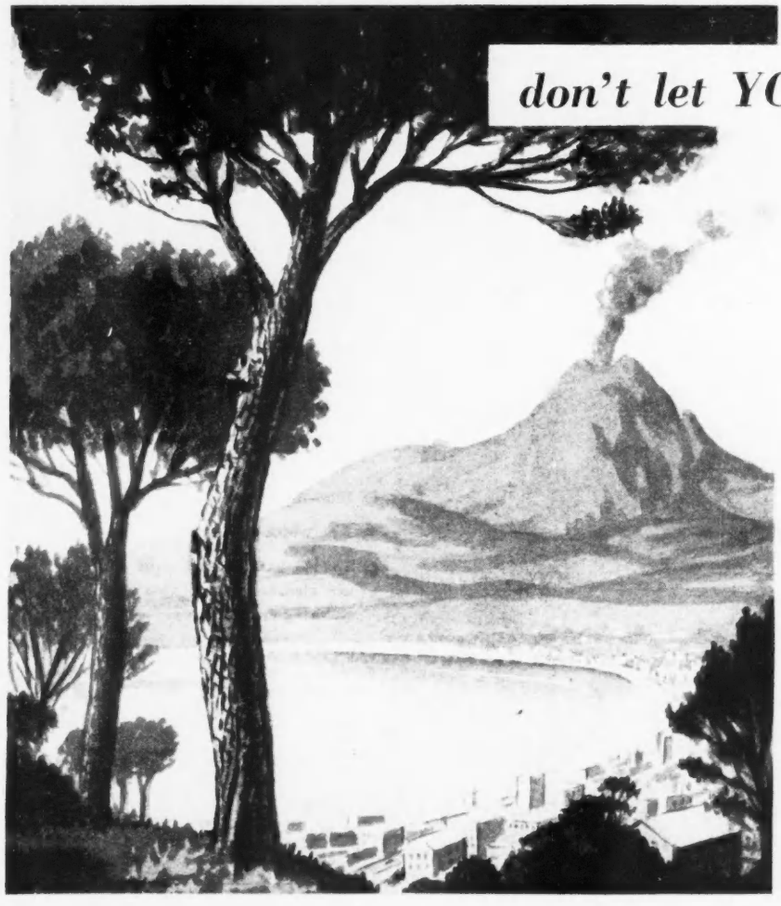

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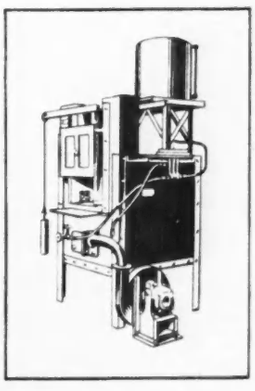

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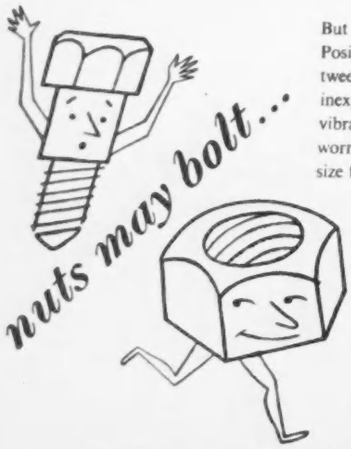

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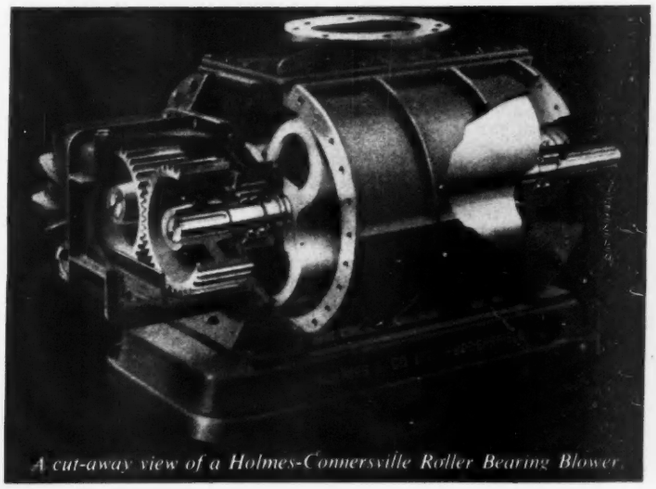
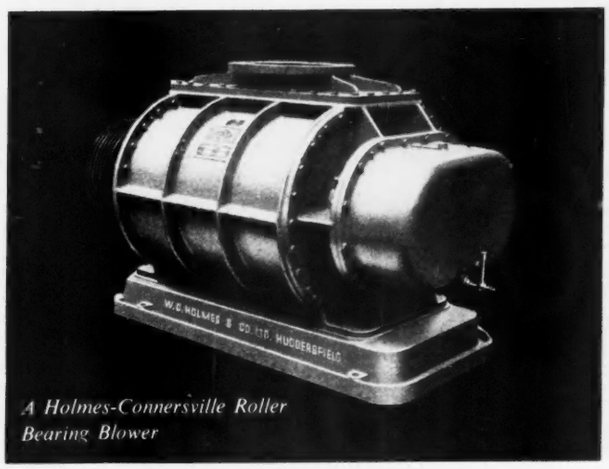


A cut-away view of a Holmes-Connersville Roller Bearing Blower



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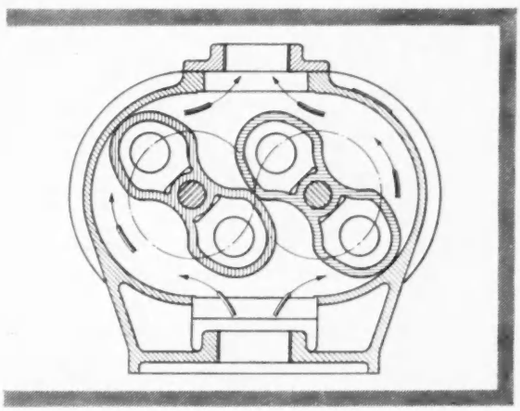

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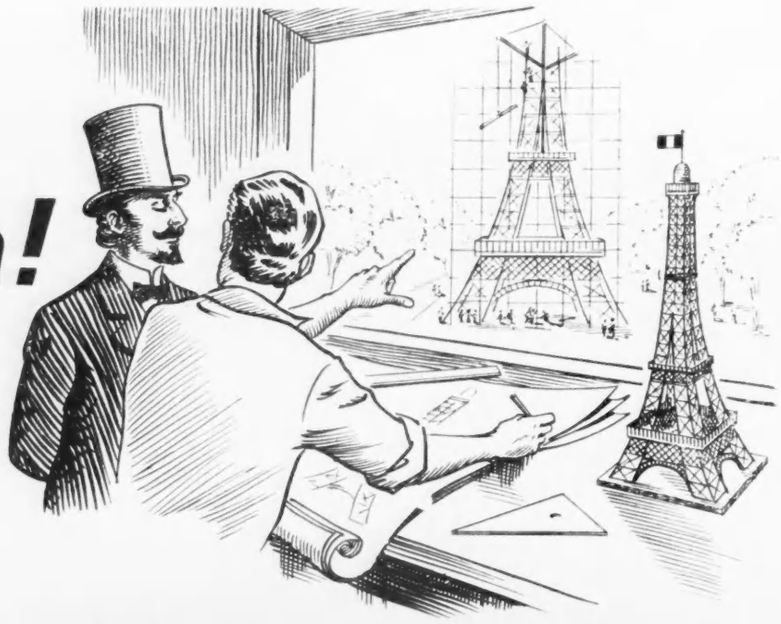

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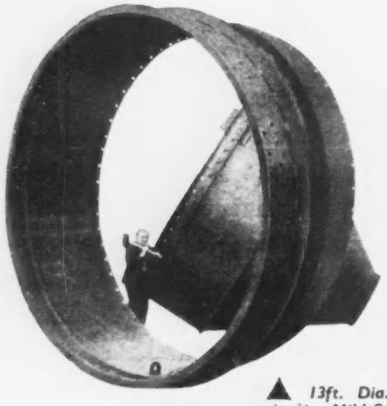

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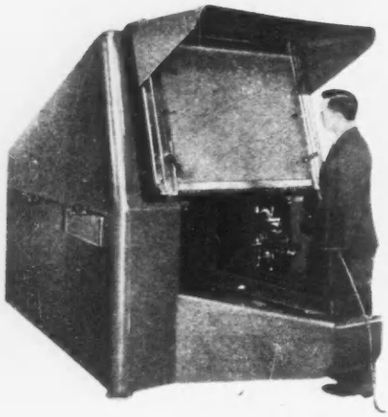

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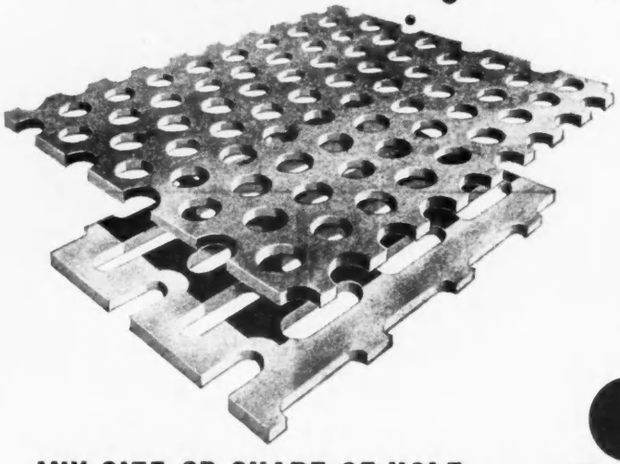

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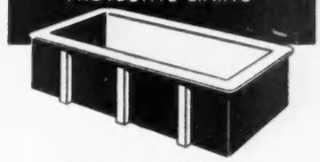

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THE ENGINEER

No. 5374 JANUARY 23, 1959 VOL. 207

DISTRIBUTING INDUSTRY

This week, the Parliamentary Secretary to the Board of Trade, Mr. John Rodgers, has written to the managing directors of over 60,000 firms throughout the United Kingdom directing attention to Government assistance which is available for the expansion of industry in certain areas. The areas are those in which the rate of unemployment is above the national average and in which the prospects of anything approaching full employment are not particularly good. The list of such areas, specified by the Board of Trade, includes parts of the Kent and East Anglian coastal districts, the Isle of Wight, and parts of Cornwall, Devon, Durham, Lancashire and Cheshire, Yorkshire, Scotland and Wales. The Government is endeavouring to deal with the problem of local unemployment in two ways that may be said to be complementary to each other. First, there is the assistance that may be obtained under the terms of the Distribution of Industry (Industrial Finance) Act, 1958. Any firm, large or small, which is considering moving into or extending in an area of high unemployment and can show that its project will reduce unemployment, may apply for a grant or a loan. The firm is required to show that it is a sound concern, likely to succeed if it obtains financial assistance, and that it cannot get the necessary facilities from the banks or other sources. The other way in which the Government is tackling the problem is by a much more critical examination of applications for industrial development certificates. For some time past these certificates have been refused to firms wishing to expand in the London area whenever it is considered that they can go elsewhere without undue loss of efficiency. The same policy now applies to other parts of the country which are industrially congested and have a low rate of unemployment. This, it is argued, is likely to react to the benefit of those parts of the country where, at present, unemployment is higher. Firms which are not permitted to expand in the industrially congested areas will, it is hoped, look for alternative sites and the attraction of a "development areas" loan may be the decisive factor in determining the location.

The Government is now obviously anxious to give its scheme some fillip. Although the relevant Act has been operating since last July, the number of applications for assistance has evidently been disappointingly small. Certainly, in recent months there has been a slowing down in industrial building and the re-expansion of investment has not yet been encouraged by the Government. It is possible, too, that many industrialists have their own reasons for being somewhat reluctant to grasp the "carrot" of a development area loan which the Government is energetically dangling. The majority of industrial concerns, we believe, prefer to decide for themselves the location best suited to their particular needs. In the long term, it may not be the best solution to move an establishment to or to build an extension in a certain area solely because it may lead to some alleviation of prevailing unemployment. Encouraging the people to move to industry—difficult though that might be—might ultimately prove far more satisfactory for all concerned than trying to persuade industry to move to the people. Nevertheless, the Board of Trade is campaigning for the latter course. Its regional controllers are glad to provide full information as to the places where labour, land and other facilities are available to establishments which are contemplating moving or expanding.

TRAINING MACHINE TOOL DESIGNERS

The unexpectedness of life can be very entertaining. Coincidences, for example, often seem to occur much more frequently than, upon a statistical study of the chances, they ought to. In our issue of December 5 we published an article by Hugh Clausen on "Training for Design." It has been followed by some correspondence; and in our last issue we discussed the point editorially and asked whether in this country we ought not to set out quite deliberately to train more designers either in universities and colleges or in the works or in both. Now, hard upon the heels of the publication of that leading article, there comes the news that one section of the engineering industry in this country does intend deliberately to train people for design. As is announced on page 149 of this issue, the Machine Tool Trades Association is to award ten scholarships every year, worth £500, for an advanced two-year course in machine tool design at the Manchester College of Science and Technology.

Ever since the war the machine tool industry of this country has suffered criticism. It has been criticised for not expanding productive capacity sufficiently rapidly; for its import policy; for its failure to make individual high production tools; for leaving to American and Continental manufacturers the making of more advanced forms of machine tools and several kinds of specialised tools, and so on. We have no desire to comment here upon those criticisms further than to remark that we think some of the critics have exaggerated the alleged misdeeds of the industry and that we think also the industry has often laid itself open to critical attack by an irritating complacency, apparent or real, in its various publications, particularly those rebutting the criticisms. But here in this week's announcement is something upon which the industry surely can be unreservedly praised. It can be all the more unreservedly praised in that the decision to award the scholarships appears to have arisen out of self-criticism within the industry. For over fifty years Continental technical colleges and universities have had Chairs in Production Technology and Machine Tools and the like, and scientific studies have been made of the basic principles of machine tool operation and design;

whereas in this country the training of machine tool designers has been left almost entirely to the industry and the subject has been treated much more as a craft to be learned by practical experience than as a science. Perhaps some of the change of heart, of which the setting-up of these scholarships provides evidence, comes from an appreciation that orthodox cutting techniques and control methods nowadays are being for some purposes superseded by new systems of which the orthodox workshop practitioners can have no knowledge at all. But some also must be derived from an increasing appreciation of the value of researches undertaken by the Production Engineering Research Association and by certain universities in this country. Whatever the reason for the change, it is to be welcomed. It is additionally to be welcomed in that what the two-year course scholars will experience is apparently really to be concerned with design as well as with scientific principles. There is, we understand, to be work on actual design projects. We shall be intensely interested to see how the experiment turns out.

PEAK-HOUR TRAVEL

Last week, Sir John Elliot, chairman of London Transport, discussed in a letter to *The Times* what remedies are available for those delays to and overcrowding in trains during London's rush hour, which build up irritation between the travelling public and station staffs and which led recently to the somewhat ill-considered " sit down " strikes amongst passengers upon hearing the cry " All change ! " Broadly he saw those remedies as the staggering of working hours, the building of the proposed new tube north-east to south-west connecting Victoria, Euston and Kings Cross, and the clearing of congested streets of parked cars and vans " so that they can once more become the avenues of movement for which they were originally designed."

There is, of course, nothing new about these proposed remedies. London Transport spokesmen, and particularly Sir John himself, have been pressing them upon the Government and upon Londoners for years past. For, possibly for some reason connected with the shortening of working hours in factories, offices and shops, &c., there has been a pronounced tendency in London (and in other cities, too !) for people almost all to want to travel to and from work at just about the same time of day, thus concentrating upon the London Transport organisation more intense peak loading than existed before the war. It cannot be doubted that were it possible to put the remedies into effect there would be some, and possibly substantial, easement of the peak load problem. Yet when a remedy is repeatedly proposed for some trouble and is nevertheless not adopted or only very partially adopted, we cannot help suspecting that it may be less easy to apply than it appears. The more obvious of Sir John's proposed remedies is that of staggering working hours. Why, if staggering could result in much more comfortable travelling conditions, economies in train and bus operation, and possibly even reduced fares, is it proving so difficult to get business firms to stagger office hours ? One reason must occur to everyone. It is that the very object of setting up offices in large cities is to ensure simplicity and rapidity of contact in person or by telephone with other offices so that business of various kinds can be carried on expeditiously. But this object can be secured only if the various offices concerned are open and in action during very similar hours each day. Thus, though staggering is certainly possible, it cannot be carried very far. Yet, because there is necessarily a time lag between, for example, the closing of any particular office and the resultant peak flow of people from that office through any given exchange station on the London Transport system it seems to us very probable that for " staggering " to be really effective in reducing peak loading it might have to amount to differences in office hours of as much as an hour morning and evening, depending upon geographical situation. Sir John's second remedy is the construction of the Victoria line tube railway through the heart of the West End. Any traveller on London's Underground who cares to study a map must be impressed by the probable effects of building this line upon the weight of passenger traffic using other lines. The easement it would create would undoubtedly be substantial. But, unfortunately, it would cost £55,000,000, including rolling stock, and Sir John himself admits it would not pay. One cannot help wondering whether some other way of spending as much money to ease London's transport problems might not prove just as effective and more profitable !

Lastly, Sir John attacks the parking of cars and vans in congested streets. He has it in mind, no doubt, that if traffic congestion could be eased the omnibuses and coaches could run faster and keep more reliably to schedule ; and that, in consequence, they would become more popular with the travelling public for the longer journeys, thus taking some of the load off the railways. But what does Sir John mean by " clearing congested streets of parked cars and vans " ? Sir John (quite rightly as chairman of London Transport) is fond of stressing the economy of public transport as against the high cost of the private car. He has seemed sometimes even to favour the banning of the private car from Central London's streets. But surely the right answer—possibly the right answer to London Transport's problem, too—is to do very soon what the expansion of London's street traffic must surely, sooner or later, force upon the authorities. The need to drive new motorways (or, if not motorways, at least new highways) across London is becoming more urgent as each year passes, and there is, in addition, an urgent need for the construction of more overpasses and underpasses at existing road junctions on the lines, for example, of those recently built in Brussels. That there should, in addition, be adequate provision for off-street parking goes without saying. For if it is true statistically that Londoners use their cars for business purposes substantially less than business men in provincial cities, that is cause not so much for satisfaction, as for alarm. Let us by all means have office hours staggered. If it can be afforded let us have the proposed new tube railway. But what seems really more essential is a much more vigorous attack than any yet made upon the problem of surface congestion.

TRAIN RESISTANCE

The resistance of railway rolling stock was referred to in an article published in our issue of December 19 last and was the subject of a subsequent letter from Dr. Tuplin, printed in our impression of January 2. It is a matter which has long been the subject of experimental investigations and has repeatedly been discussed in our pages. The actual resistance to traction by a train of vehicles during a specific test can, of course, be definitely determined. The resulting resistance values hold good for such a trial under the conditions ruling and the specific resistance per ton for level track conditions then determined are valid. This is, however, very different from establishing a precise value for general application

when estimating the hauling capabilities of a locomotive.

Of the data required for solving such problems, the train resistance component is, or seems to be, the least reliable ; in fact, it is seen to vary even when tests carried out by the same investigator are compared. As cases in point, the figure derived from trials carried out on the Western Region, British Railways, with a " King " class engine hauling a heavy train of passenger stock appears to indicate a specific resistance of 8·5 lb per ton on a level track at 60 m.p.h., which compares with a value of 10·33 lb per ton at the same speed, according to Mr. Nock's article in our December 19 issue, and which is stated to be applicable to current rolling stock. Other tests carried out on another region, again with a heavy train of passenger stock, show a resistance of 9·5 lb per ton, also at 60 m.p.h. Other values for train resistances at various speeds on a level tangent track are those given by Sir W. Stanier in a paper presented to the British Association in 1936, which indicate a resistance of about 11·1 lb per ton at 60 m.p.h. The figures quoted show considerable differences, even though they apply to trains presumably made up of reasonably modern passenger coaches probably in good average condition, which is no doubt an important factor.

Another consideration to be taken into account is the nature of the road. In this connection, some experiments carried out by the Association of American Railways in 1938 are not without interest. The particular tests we have in mind were conducted to establish the power required to operate a 1000-ton passenger train at 100 m.p.h., but at the same time observations were made with the idea of determining the resistance offered by the train when running on a level tangent track at high speeds. These tests were made with one sixteen-car train operating over three different railways having rails of 131 lb and, approximately, 100 lb per yard. The former applied to the Pennsylvania when the train resistance was estimated to be about 6·3 lb per ton on a level tangent at 60 m.p.h., comparing with about 7·4 lb and 7·9 lb for the other two lines. The Pennsylvania line was ballasted with crushed limestone, while the others appea. to have had a somewhat lighter type of ballast. These figures are, it is admitted, hardly applicable to conditions here, principally because the car weights were higher than those in this country, averaging 62 short tons each ; they do, however, indicate the influence of track characteristics on the resistance of railway vehicles. Any reduction in the resistance of passenger coaches which may have taken place during the last few decades is quite possibly largely due to an improved track with more efficient upkeep than to the actual design of rolling stock as normally used, though here, again, maintenance no doubt is a ruling factor. In so far as any experiments designed to establish actual resistances are concerned, while they are without doubt important, how far they reflect actual resistances is debatable. Ample allowances, often unexpectedly large, must be therefore made when estimating locomotive performance and framing scheduled timings. Precise resistance values for computing drawbar tractive efforts hardly appear possible ; practical experience must surely often largely decide what can be attempted ; and, further, road conditions must be an important consideration.

MASS RADIOGRAPHY FOR MINERS

The National Coal Board's scheme to introduce regular X-ray examination of all mineworkers is an important step towards the control of pneumoconiosis. The frontal attack on this disease, of course, is by preventing or suppressing the dust which is an inevitable but unwanted by-product of the actual mining operation and the Board is fully alive to the need for limiting the amount of dust which can be inhaled by miners. But as long as it is impracticable to remove all the dust from the atmosphere in mines it is clearly essential to know what concentrations of dust can be regarded as tolerable. The introduction of mass radiography on a national basis should provide much needed statistical information about pneumoconiosis—the incidence of the disease and its progress and control, the susceptibility of individual miners, and the safety levels of dust concentration.

The scheme is described on page 147. Using a fleet of nine self-contained mobile radiography stations the National Coal Board proposes to provide a regular service which will enable every miner to undergo X-ray examination at regular intervals. Initially it is intended that the examinations should be repeated every five years, but according to the experience gained with the scheme the interval may be varied as required to ensure that the presence of pneumoconiosis can be detected as soon as possible after its onset. Since the success of the scheme will depend upon the active co-operation of the miners, the X-ray examinations will be voluntary and all the results obtained will be confidential between the individual and the Board's Medical Service. An interesting sidelight on the attitude of the mineworkers is contained in the Board's statement that in the areas where radiography has been introduced on an experimental basis, about 90 per cent of those eligible have accepted the service. Such a response augurs well for the success of a new system which promises to play a major part in improving the health of miners, limiting the incidence of pneumoconiosis and removing one cause of wastage amongst some of the most skilled and experienced men in the industry.

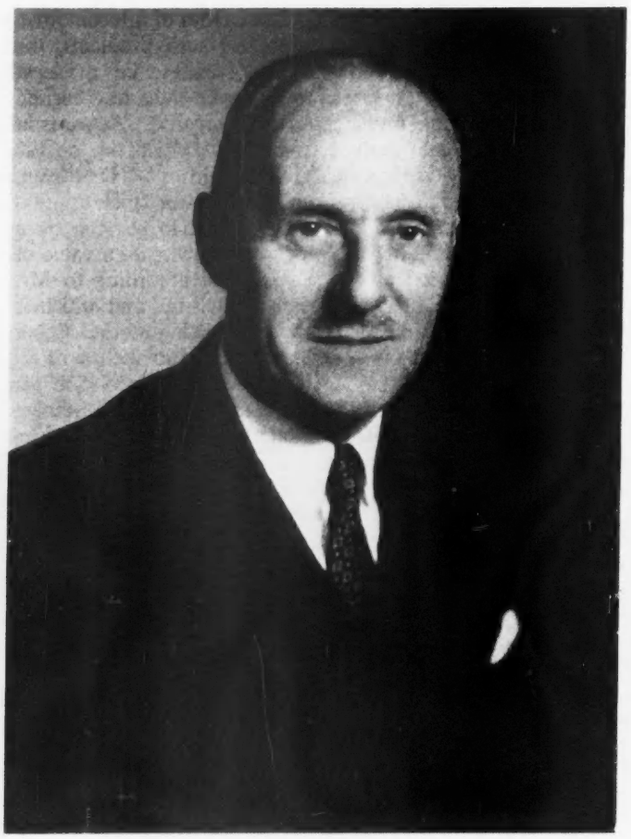
The Engineer—100 Years Ago (JANUARY 21, 1859)

" AGRICULTURAL IMPROVEMENT "

" The great and rapid concentration of population within the limits of large towns has furnished by far the most powerful stimulant to agricultural improvement. With slovenly farming, and wretched means of communication, the cost of living, as measured by the price of labour, would have been beyond the means of many of the millions who are now clustered in our great commercial and manufacturing capitals. . . . It is only within the last three or four years that agriculture has come to be regarded in its proper light. The farm is at length looked upon as a vast laboratory, a great manufactory to be worked upon exact scientific principles, with the aid of every appliance which can in any way increase its capacity. . . .

" The more the culture of food is regarded in the light of a practical manufacture, the more clearly do we see in the adaptation of complete machinery to all of its mechanical processes, and in the supply of artificial warmth, moisture, and assimilative matter, the certain attainment of continuous and heavy crops. There can be no doubt that farming will ultimately be generally conducted upon a large scale, with all the aids of capital, machinery, skilled and organised labour, and, above all, under thoroughly scientific and practical management. In no other branch of human industry is more improvement possible or likely of early attainment than in agriculture, and in this movement now going on may be perceived the prospect of an immense field of operations for a new class of professional men, who, as agricultural engineers, are likely to attain a dignity and influence by no means inferior to that at present enjoyed by those to whom the title of 'engineer' is now more strictly limited."

Sir Claude Gibb, K.B.E., F.R.S.



THIS country has lost one of its most distinguished engineers by the death of Sir Claude Dixon Gibb, which occurred suddenly at Newark Airport, New Jersey, on January 15. Sir Claude was on his way from Knoxville, Tennessee, to Toronto and had just left the aircraft during its brief stop at Newark when he collapsed. Sir Claude, who was sixty, was chairman and managing director of C. A. Parsons and Co., Ltd., and chairman of the Nuclear Power Plant Company, Ltd., Anglo-Great Lakes Corporation, Ltd., and the Parolle Electrical Plant Company, Ltd. He was also a director of A. Reyrolle and Co., Ltd., from the chairmanship of which company he had recently resigned owing to his many other commitments.

Sir Claude was born at Queenstown, South Australia, and studied at the South Australian School of Mines and Industries and at Adelaide University where he gained the degrees of Bachelor and Master in Engineering. After serving during the first world war as a pilot officer in the Australian Flying Corps, Sir Claude spent three years or so as a research administrator and chief assistant to Sir Robert Chapman, professor of engineering at Adelaide University. In order to extend his practical experience, Sir Claude came to this country early in 1924 and started work with C. A. Parsons and Co., Ltd., Newcastle upon Tyne. It marked the beginning of an outstanding period of service with the firm of which he subsequently became the head. Shortly after his arrival in this country, Sir Claude learned that he had secured the Angus engineering research scholarship, Australia's premier engineering award. He spent a year as a fitter in the erecting shop at the Heaton works, moved on to a period in the design and drawing offices, and was next appointed to special duties on the company's outside erection staff. During that time he was engaged also in research problems concerned with turbine operation, an activity which led to his being appointed test house manager in February, 1927. In the succeeding months extensive re-organisation and re-equipment of the company's test plant were carried out under Sir Claude's supervision. Early in 1929, he became chief operating and test engineer and in May of that year the late Sir Charles Parsons appointed him technical director of the company.

Sir Claude became general manager of C. A. Parsons and Co., Ltd., in 1937. Shortly after the outbreak of the second world war, however, he was seconded for service with the Ministry of Supply, becoming engineering assistant and, later, deputy to the director-general of munitions production, director-general weapons and instrument production, director-general armoured fighting vehicles, and, in 1944, chairman of the Tank Board. Sir Claude's great service in those offices were recognised by the conferment of the C.B.E. in 1942 and of a knighthood in 1945. He was created a K.B.E. in 1956. At the end of the war, Sir Claude returned to C. A. Parsons and Co., Ltd., to take up the joint responsibilities of chairman and managing director. Under his wise leadership, the company embarked upon a period of considerable expansion. Extensions to the works were carried out; the output of generating plant rapidly increased as did the size of its products. As an example, it may be recalled that in 1945 the largest turbo-generator set on order was designed for an output of 52·5MW whilst last year the company received an order for a 550MW set.

It was characteristic of Sir Claude that he should have been one of the first British industrialists to take an active part in the development of power from nuclear reactors. He was prominent in the early discussions which centred around "PIPPA," a reactor project study which proved to be the forerunner of the Calder Hall nuclear power station. At Calder Hall his firm, C. A. Parsons and Co., Ltd., was responsible for supplying all the generating plant, gas circulators and ductwork. Similar plant was later installed at the Chapelcross nuclear power station. Sir Claude was a prime mover in the formation of the Nuclear Power Plant Company, Ltd., a consortium of eight firms which collaborate in the construction of complete nuclear power stations. This company, under its founder chairman, Sir Claude, contracted to build one of the first three commercial nuclear power stations in this country, at Bradwell, Essex. The order for this 300MW station was placed in 1957, and commercial production of electricity is expected to begin in 1960–61.

In the meantime it had become apparent with the publication of the British nuclear power station programme in 1956 that progress, initially at any rate, depended on the use of graphite as the moderator in the reactor core. To increase the supplies of high density graphite Sir Claude was instrumental in forming a new company, the Anglo-Great Lakes Corporation, Ltd. Within seventeen months of starting work on the building of a factory on a site adjoining Stella North power station, samples of graphite were being made and the designed production capacity of this factory is 10,000 tons of nuclear graphite a year.

In the last few years of his life much of Sir Claude's energy was devoted to the export of nuclear reactors. He soon appreciated that the opportunities for complete "turn-key" contracts overseas were limited but that there was a good deal of scope for the export of "know-how" to countries that had enough technical ability to collaborate in the building of nuclear power stations. The first fruit of this concept was the conclusion of a long-term agreement, signed last year by Sir Claude as chairman of the Nuclear Power Plant Company, Ltd., and Sr. Enrico Mattei president of A.G.I.P. Nucleare, to collaborate in the building of nuclear power stations in Italy. In particular a contract was made to build the Latina power station near Rome —the first export contract for a nuclear power station anywhere in the world.

This record of Sir Claude's achievements in the fields of electrical and nuclear engineering emphasises the valuable contribution which he made to the work of his company during his thirty-five years of service with it. But his work was by no means limited to the affairs of his company. By his articles to the technical press—THE ENGINEER has had the privilege of printing a number of them—by papers and lectures to engineering institutions and other learned societies, and by his keen interest in technical education, Sir Claude has made a classic contribution to the advancement of scientific knowledge. His papers to learned societies in this country and overseas covered a variety of subjects including steam turbines, generators, gas turbines, fuel usage and nuclear power. One of his earliest contributions to the proceedings of the Institution of Mechanical Engineers was a paper, in 1934, entitled "The Evolution of Design," and one of outstanding value was that, presented in 1955, on "The Failure of two 100MW Turbo-Generators." This paper described in detail investigations which were made following the failure of two generators installed in the Richard L. Hearn station at Toronto. In presenting that paper, Sir Claude characteristically said that often "progress is made by solving the problems resulting from the making of progress." Another of Sir Claude's contributions to the "Mechanicals" was the Parsons Memorial Lecture in 1947 which he appropriately entitled "Parsons : The Man and His Work." Sir Claude was at all times ready to acknowledge the benefit that he had derived from the work and inspiration of others. Of himself and his philosophy he once said, for example, "I have had three heroes in my life. Professor Sir Robert Chapman, a great teacher ; Sir Charles Parsons, a great engineer ; Engineer Vice-Admiral Sir Harold Brown, my war boss, engineering chief of the Fleet and Director-General of Munitions Production, who built the superstructure of the rearmament drive, a great man. I was assistant to these three men and they all had a profound

effect on my make-up and approach to life. The first taught me clarity of thought as a prime essential ; the second taught me what engineering genius and hard work can do for mankind ; the third taught me that leadership and loyalty to your staff are perhaps in the end the greatest contribution to life a man can make."

Sir Claude was elected a Fellow of the Royal Society in 1946, and a vice-president in 1957 ; he also received honorary degrees of Doctor of Science (Engineering) in the University of London, and Doctor of Science in the University of Durham. He became an Associate Member of the Institution of Mechanical Engineers in 1926 and was transferred to full membership in 1929. For twenty-two years, Sir Claude served on the Institution's council and for eight of them as a vice-president. But the pressure of his many duties prevented him from accepting nomination as president. We have already mentioned some of the papers which he presented to the "Mechanicals," and on two occasions, in 1932 and again in 1956, he was awarded the Thomas Hawksley gold medal.

It is tragic that so great a man as Sir Claude Gibb should have died at what must nowadays be regarded as a comparatively early age. Yet it could be foreseen that he would die comparatively young. For consistently over the years Sir Claude overworked. His intensely active and interested mind refused his body adequate rest ; and he packed into a lifetime shorter than that of most other men far more experience than most men acquire. Sir Claude's was a forceful personality. But there was nothing unpleasant about his forcefulness. He knew his own mind ; he had discovered by experience that his intelligence and his judgment were of very high quality ; he had faith therefore in his own ideas and he was ready to fight hard (particularly with a persuasive tongue) to get them adopted. But he held in high regard courageous opponents and all who honestly held and boldly expressed opinions different from his own. Moreover he had the faculty of suggesting to almost all those he met that he liked them and wanted to talk with them. He could, indeed, talk easily with all and sundry. This charm of manner softened his forcefulness ; in his later years it made him as admirable in negotiation as earlier he had been brilliant academically inspired practically and outstanding as a leader of men.

Britain and the Commonwealth by Sir Claude's death have lost suddenly a very great man. Yet those who knew Sir Claude, once they have got over the shock of learning of his sudden death, will we think realise that it was not surprising. For that his death should be sudden and relatively early was an almost inevitable outcome of his character. Nor would Sir Claude have had it otherwise. Indeed, we cannot believe that he would have tolerated with patience the growing physical weakness that comes with increasing age nor any suspicion that his intellectual ability might be failing him. Sir Claude would never, in fact, have fitted into the conception of a man enjoying a serene old age. It will be a particular satisfaction to everyone that he lived just long enough to have bestowed upon him the highest award that the Institution of Mechanical Engineers can confer, the James Watt International Medal. It was to have been actually presented to him to-night at a meeting of that Institution. Sadly he lived not quite long enough personally to receive it. Arrangements are being made for Lady Gibb to receive it.

Non-Uniform Burning in a High Speed Parallel Sided Combustor

By BORIS N. COLE, Ph.D., Wh.Sc., A.M.I.Mech.E.*

No. II—(*Concluded from page 95, January 16*)

As the need for compactness increases in gas turbines and jet propulsion systems, so must the air velocities through the combustion chamber increase, leading to throughput Mach numbers of substantial value in the sub-sonic scale. The liberation of heat in such streams causes—quite apart from the collateral action of aerodynamic drag—a considerable departure from the constant-pressure combustion "law" so commonly assumed in elementary cycle analyses. For varied reasons, combustion may often be confined to a fraction only of the total air-stream, with the result that many flow systems are at least binary in character ; in this sense, the combustion is "non-uniform." The so-called "fundamental pressure drop" for the chamber, and the momentum of the efflux, then depend on two main factors : (i) the degree to which combustion has been confined, and (ii) the efficacy of the arrangements for mixing the combustion gases with the remaining air flow. A fundamental review of the problem is presented in terms of one-dimensional reasoning. This basis has been adopted on the grounds that its admitted inadequacies in detail are heavily compensated by its manageability in numerical analysis over a wide range of variables. Three flow models are proposed and examined, and attention is also given to aspects of flame length and post-combustion dilution mixing. Specimen calculations are given at all stages.

Numerical Procedures.—Owing to the awkward powers associated with the static pressure ratio, x, certain approaches to numerical work are hampered by the occurrence of trial-and-error solutions. This difficulty can be avoided in many cases if x itself be treated as an independent variable ; and two particular numerical approaches will be discussed on this basis, calling for certain re-arrangements of the equations.

In the first case, numerical values are assigned to M_1, T_{o1} (hence T_1), and to the amount of heat released per pound of total flow (i.e. including both hot and cold streams) ; the object being to discover how the downstream flow conditions are affected by concentrating this fixed investment of heat liberation into a small, or large, proportion of the total stream. Denoting the heat per pound of total flow by q_t, the following relation will obtain :

$$\frac{q_t}{C_p \cdot T_{o1}} = \left(\frac{T_{oh2}}{T_{o1}} - 1\right) \cdot \theta_1 = (\text{say}) Q = \text{constant}$$

or

$$\frac{T_{oh2}}{T_{o1}} = \frac{Q}{\theta_1} + 1 \qquad \ldots\ldots (17)$$

Equations (12) and (14) may be substituted in (15) to eliminate θ and M_h. The resulting expression for T_h/T_1 may then be combined with equations (16) and (17) to eliminate all temperature terms, leading, after simplification, to the following relationship :

$$\theta_1 = \frac{F_3 \cdot F_5}{Q \cdot F_2 - F_3 \cdot F_6 - F_4 \cdot F_5} \qquad \ldots (18)$$

which, for the case of $\theta_1 = 1$, reduces to the terms of equations (8), (9) and (10), as prescribed for the case of uniform burning over the entire cross section. The definition sequence for the functional symbols F, as given in the list of notation, has been contrived out of regard for convenience in numerical work. Thus, with M_1 and Q chosen, a succession of x values may be applied to equation (18), yielding corresponding values of θ_1 ; remaining quantities follow without further difficulty from (11), (12), (14), (15) and (17). In planning such a series of calculations, it is desirable to deal first with the case of $\theta_1 = 1$, for which x can be evaluated directly by means of equations (8), (9) and (10) ; values of x subsequently chosen must lie between this limiting value and unity, all other values being incompatible with the M_1 and Q values already adopted.

Specimen calculations developed in this way are shown in Fig. 3, for which the assumed constants are : $M_1 = 0{\cdot}3$; $\gamma = 7/5$; $T_{o1} = 700$ deg. Fah. abs. ; $q_t = 240$ B.Th.U. per pound of total flow ; so that $Q = 1{\cdot}4286$. It will be seen that, as θ_1 falls off from unity, the hot stream divergence ratio, θ_2/θ_1, and the static pressure ratio, x, increase appreciably ; there is a simultaneous decrease in the final Mach numbers, M_{c2} and M_{h2}, the former value, however, consistently exceeding the latter.

For the second approach to numerical work, a fixed value may be assigned to the calorific value, q, of the hot stream alone ; so that, with M_1 and T_{o1} fixed as before, a constant value is automatically given to T_{oh2}, according to the relation

$$\frac{q}{C_p \cdot T_{o1}} = \frac{T_{oh2}}{T_{o1}} - 1 = \text{constant} = \frac{Q}{\theta_1} \qquad \ldots\ldots (19)$$

Equations (18) and (19) may therefore be combined to give the following quadratic expression for the evaluation of θ_1 for any chosen value of x :

$$F_2 \cdot \left(\frac{T_{oh2}}{T_{o1}} - 1\right) \cdot \theta_1^2 - (F_3 \cdot F_6 + F_4 \cdot F_5) \cdot \theta_1 - F_3 \cdot F_5 = 0 \qquad \ldots (20)$$

Of the two roots occurring, one is negative, and is thus dismissed as being physically absurd. In this case, choice of a realistic series of x values is assisted by applying the selected value of T_{oh2}/T_{o1} to equations (8), (9) and (10), so as to determine the minimum value of x that is compatible with the assumed constants. When a sequence of θ_1-versus-x calculations has thus been completed on the basis of equation (20), the work of evaluating other corresponding magnitudes evolves as for the former procedure ; and it will be evident that many of the detailed calculations arising in the first procedure can often be re-used in the second.

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Specimen calculations based on this latter procedure are illustrated in Fig. 4, the relevant constants being : $M_1=0{\cdot}3$; $\gamma=7/5$; and $T_{oh2}/T_{o1}=2{\cdot}5$. Here again, the considerable departures which can occur relatively to the state of uniform burning ($\theta_1=1$) are shown.

With regard to the magnitude of calorific value that one may assume during numerical work, it is as well to recall that the practical upper limit to this quantity will be set by the stoichiometric properties of the real carburetted stream. However, even within this limitation, it will sometimes be found in exploratory numerical work that certain calorific values apparently lead to physically meaningless results—such as a downstream Mach number of imaginary value. The correct interpretation of such an apparent impasse is that the chosen calorific value is incompatible—through the intervention of sonic "choking"—with assumed Mach number of approach, M_1 ; and that, if this heat release rate be forced upon the system the entire flow will re-adjust itself until the approach Mach number is reduced to a compatible level. One must therefore choose between insisting upon the selected calorific value and accepting a modified steady state, and insisting upon the selected approach conditions and accepting a more modest calorific value.

Non-Uniform Burning With a Very Short Flame, or With an Internal, Parallel-Sided Flame Tube

The second case to be considered is that for which the flame length is so small as to warrant replacement, for analytical purposes, by a simple plane of stagnation temperature discontinuity. The flow model thus defined is shown in Fig. 1 (*b*) (*ante*).

In approaching this problem, it is clearly broadly permissible (with reservations which will become apparent) to apply equations (8), (9) and (10), which relate to flow through a normal thin flame, to describe the transition within the carburetted stream from plane 2 to plane 3. However, any inclination to suppose that the cold and carburetted stream may have equal Mach numbers and, in particular, equal static pressures right up to plane 2 must be examined carefully. The implications of this supposition are as follows : (i) the cold stream will proceed through the infinitesimal distance separating planes 2 and 3 without change in any physical quantity ; (ii) the hot stream, on reaching plane 3, will have accelerated, and thereby lost a certain amount of static pressure ; (iii) accordingly at plane 3, there would seem to be contiguous parallel streams of gas, across the common (slip) surface of which there is a discontinuity in static pressure. In an obviously unstable state, the cold stream would seek equilibrium by dilating against the hot stream, progressively with distance along the duct downstream of plane 2 ; simultaneously, however, the cold stream would decelerate, with gain in static pressure ; while the hot stream, being made to converge, would accelerate and lose even further in static pressure. Ostensibly, then, the static pressure difference across the separation surface would accumulate with distance instead of dissipate ; and it becomes at once clear that a completely untenable system would result from the postulate of uniform transverse distribution of static pressure over plane 2. Within the confines of a one-dimensional treatment, the only means of avoiding this difficulty is to adopt assumption 7 ; namely, that the static pressure distribution is uniform over plane 3 ; and to accept in result thereof that the carburetted stream will retard, and, thus gaining in static pressure, "pile up" against the upstream face of the flame in the manner suggested in Fig. 1 (*b*). (In support of this argument, it is worth pointing out that if the duct terminated shortly after plane 3, so that the sub-sonic binary stream discharged with negligible mixing to atmosphere, the static pressure distribution over the exit plane would automatically adjust itself to uniformity.)

The piling up process suggested would be crudely analogous to that associated with flow past an obstructing flat plate, which (see Foettinger, 1939) is known to entail a highly localised re-arrangement of the erstwhile parallel streamlines on the upstream face ; though the present "obstruction"—the flame—is, of course, of an essentially permeable nature. The broad inference is, however, that the flow upstream of the flame must re-arrange itself from the uniform approach state indicated for the relatively remote upstream station 1 to terms of a divergent retardation of the carburetted stream, accompanied by a convergent acceleration of the cold stream ; the static pressure difference thus created over the breadth of plane 2 being sustained be the lateral accelerations accompanying direction change within the two families of streamlines.

At this stage, it is evident that the problem is properly of at least a two-dimensional character; and that to describe the behaviour of either the hot or cold stream across plane 2 by single values of pressure, velocity, &c., is, in fact, to work in terms of somewhat nebulous mean values of those quantities. While to persist with one-dimensional analysis must tax such method beyond its normal limits of reliability, an outline treatment will nevertheless be given, on the grounds that it should at least serve as an "order of magnitude theory"; for there is little doubt that a rigorous treatment would be incapable of expression succinct enough for general numerical work.

The convergent flow of the cold stream between planes 1 and 2 will be adequately described by equations (11) and (12) as they stand ; which means that the symbol x is now attached to the cold stream only. For the hot stream, the isentropic retardation envisaged between the same planes leads to the following expressions :

$$M_{h2}^2=\frac{M_1^2+\frac{2}{\gamma-1}\left(1-X^{\frac{\gamma-1}{\gamma}}\right)}{X^{\frac{\gamma-1}{\gamma}}} \quad . \quad . \quad (21)$$

and

$$\frac{\theta}{\theta_1}=\frac{1}{X^{\frac{1}{\gamma}}\sqrt{1+\frac{1}{M_1^2}\cdot\frac{2}{\gamma-1}\left(1-X^{\frac{\gamma-1}{\gamma}}\right)}} \quad . \quad . \quad . \quad . \quad . \quad (22)$$

where

$$X=P_{h2}/P_1 ; \text{ so that, since } P_{c2}=P_{c3}=P_{h3}=P_3 ;$$

$$P_{c2}/P_1=x=X\,.\,(P_3/P_{h2}) \quad . \quad . \quad . \quad (23)$$

Also, equations (8), (9) and (10) yield the following relations :

$$\frac{P_3}{P_{h2}}=\frac{1+\gamma M_{h2}^2}{1+\gamma M_{h3}^2} \quad . \quad . \quad . \quad (24)$$

and

$$\frac{T_{oh3}}{T_{o1}}=\left(\frac{1+\gamma M_{h2}^2}{1+\gamma M_{h3}^2}\right)^2\cdot\left(\frac{M_{h3}}{M_{h2}}\right)^2\times\left(\frac{1+\frac{\gamma-1}{2}M_{h3}^2}{1+\frac{\gamma-1}{2}M_{h2}^2}\right) \quad . \quad (25)$$

A numerical procedure consistent with the second approach suggested for the analysis of long-flame combustion is as follows :

(1) Choose values for M_1, T_{o1} and q, thus also fixing T_{oh3}.

(2) Select a number of values for X, which must lie between unity and the limiting value corresponding to the case of $M_{h2}=0$ in equation (21).

(3) Thence determine corresponding values of M_{h2} from (21) ; M_{h3} from (25) ; P_3/P_{h2} from (24) ; x from (23) ; M_{c2} from (11) ; and θ_1 and θ_2 from (12) and (22).

Specimen calculations have been carried out for the same numerical data as assumed for Fig. 4, on which the results are shown for comparison with those for the long-flame treatment. So far as overall numerical effects are concerned it is seen that there is no marked difference between the two cases.

In concluding this section attention is drawn to the fact that the above equations, which have been presented as a first approximation theory for the effects of a thin flame standing across part of a free stream, have equal bearing upon the system shown in Fig. 1 (*c*)—that of an internal, parallel-sided flame tube; and it is arguable that this model provides a somewhat more acceptable context. It remains only to point out that, in thus extending the field of application of these equations, it is no longer necessary to insist upon the flame (which is now enclosed) being thin ; and a finite combustion zone has accordingly been indicated in Fig. 1 (*c*).

Notation.

Dimensional symbols :

a—Acoustic velocity $=\sqrt{\gamma\,.\,g\,.\,R\,.\,T}$ feet per second.
A, A—Cross-sectional area of flow, in square feet.
C_p—Specific heat at constant pressure $=0{\cdot}2400$ for air.
C_v—Specific heat at constant volume $=0{\cdot}1714$ for air.
g—Acceleration due to gravity $=32{\cdot}2$ft per second.^{2}
G—Rate of mass flow in pounds per second.
J—Joule's equivalent $=778$ft lb per B.Th.U.
P—Static pressure in pound per square foot absolute.
P_o—Stagnation pressure in pounds per square foot absolute.
q—Calorific value of carburetted gas in B.Th.U. per pound.
R—Gas constant $=53{\cdot}3$ft lb per pound .deg. Fah. for air.
s—Distance along duct, in feet.
t—Time in seconds.
T—Static temperature in deg. Fah. absolute.
T_o—Stagnation temperature in deg. Fah. absolute.
w—Particle velocity in feet per second.
ρ—Density in pounds per cubic foot.

Dimensionless symbols :

γ—Ratio of specific heats $=C_p/C_v=7/5$ for air.
M—Mach number of flow $=w/a$.
θ—Fraction of cross-sectional area of duct occupied by the hot, or carburetted, stream.
ψ—Ratio by mass flow of stream "b" to total stream.
Q—"Dimensionless calorific value" of total gas stream (see equation (17)).
x, X—Static pressure ratio P/P_1.
y—Stagnation temperature ratio T_o/T_{o1}.

Subscripts :

o—Denoting stagnation conditions.
1—Approach conditions.
2, 3, 4—Downstream conditions (for contexts see Fig. 1).
a, b—General distinguishing symbols for the elements of a binary stream prior to mixing.
c—Denoting the cold, or chemically inert, stream.
h—Denoting the hot, or carburetted, stream.

Functional symbols :

$$F_1\equiv\sqrt{1+\frac{2}{\gamma-1}\cdot\frac{1}{M_1^2}\left(1-x^{\frac{\gamma-1}{\gamma}}\right)}$$

$$F_2\equiv M_1^2\left(1+\frac{\gamma-1}{2}\cdot M_1^2\right)$$

$$F_3\equiv\frac{1}{\gamma}(1-x)+M_1^2(1-F_1)$$

$$F_4\equiv M_1^2\,.\,F_1$$

$$F_5\equiv x-\frac{x}{F_1}^{\frac{\gamma-1}{\gamma}}+\frac{\gamma-1}{2}\,.\,F_3$$

$$F_6\equiv\frac{x}{F_1}^{\frac{\gamma-1}{\gamma}}+\frac{\gamma-1}{2}\,.\,F_4$$

$$\alpha\equiv\frac{\psi\,.\,M_b\sqrt{\frac{\gamma}{1+\frac{\gamma-1}{2}\,.\,M_b^2}}+(1-\psi)\,.\,M_c\sqrt{\frac{1}{1+\frac{\gamma-1}{2}\,.\,M_c^2}}}{\sqrt{\psi(\gamma-1)+1}}$$

$$\beta\equiv\frac{\frac{\psi}{M_b}\cdot\sqrt{\frac{\gamma}{1+\frac{\gamma-1}{2}\,.\,M_b^2}}+\frac{(1-\psi)}{M_c}\sqrt{\frac{1}{1+\frac{\gamma-1}{2}\,.\,M_c^2}}}{\sqrt{\psi(\gamma-1)+1}}$$

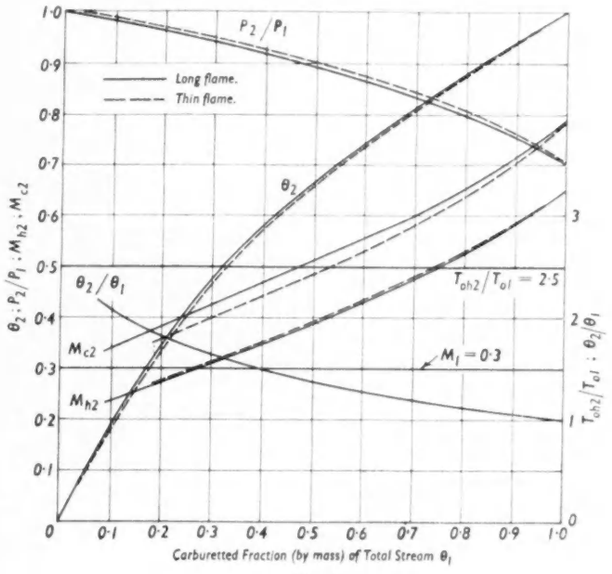

Fig. 3

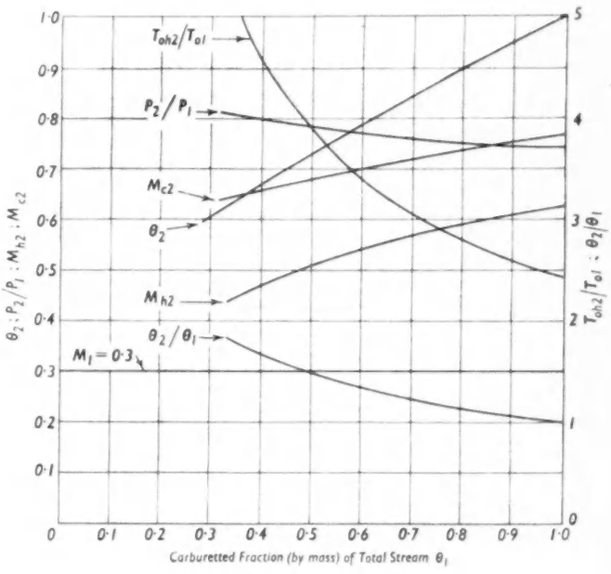

Fig. 4

Steady State Modifications

If the assumed binary flow system proceeds in the steady state without combustion of the carburetted stream, then the present treatment reduces to the simplest possible case of a single isentropic stream; which, in many applications, will discharge to atmosphere, either directly or by way of a convergent, or convergent-divergent, nozzle. Upon igniting the carburetted stream, the system will enter a brief transient period during which, by the agency of various wave effects, it will modify itself broadly to the terms of one or other of the foregoing analyses; being complicated to greater or lesser degree by the extent to which mixing of the hot and cold streams may occur before final efflux. Since, however, the exit static pressure for sub-sonic flow will be determined at all times by the constant pressure of the atmosphere, the static pressure in the upstream region 1 will increase, constituting a build-up in the back pressure on the compressor supplying the chamber; the approach conditions will thus be modified in a way which depends not only upon the rate of heat liberation, but upon the characteristics of the compressor itself. Qualitatively, the same events will be brought into play if the fuel supply rate is suddenly increased (corresponding to increases in q and/or θ_1). These considerations should therefore be kept in mind when examining such charts as Figs. 3 and 4, which are based upon constant approach conditions.

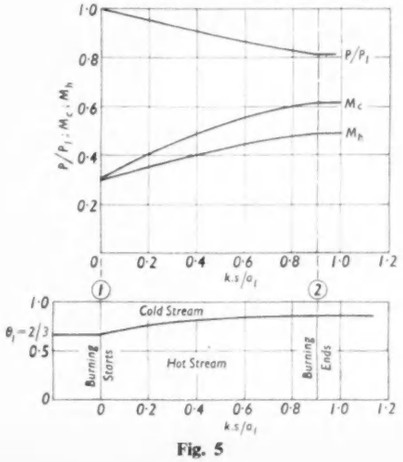

Fig. 5

Depending on the nature of the compressor, various assumptions may be adduced to forecast the modified steady state, given the initial, pre-combustion state. For example, Foa and Rudinger (1949), in dealing with the case of uniform combustive flow, consider the possibilities of (i) maintained values of upstream stagnation pressure and temperature, which entails a change in rate of mass flow; and (ii) maintained values of mass flow and upstream stagnation temperature which entails a change in stagnation pressure. Such assumptions may, of course, be applied with equal usefulness to the present binary, or any other, flow system.

Time and Distance Relationships for a Long Flame

By the terms of their governing assumptions, the main results so far quoted in description of the overall effects of heat liberation are independent of time and axial distance. However, the results may readily be combined with any available coefficient or function defining the mean effective time-rate of heat liberation of unit mass of carburetted gas to develop a self-consistent picture of how the state of flow in both cold and hot streams varies with distance along the duct; leading, in particular, to an estimate of the total length of flame.

Owing to the awkward powers associated with the static pressure ratio, x, it is best to treat x as the independent variable, and the distance s, reckoned from plane 1 (Fig. 1 (*a*)), as the dependent variable. Thus, considering the passage of an average mass unit of burning gas through an elementary distance ds, and denoting by dt the time required for a given particle to travel this distance, the following identity may be used as a starting point :

$$\frac{ds}{dx} \equiv \frac{dQ}{dx} \cdot \frac{dt}{dQ} \cdot \frac{ds}{dt} \quad . \quad . \quad . \quad (26)$$

in which dQ/dt is regarded as a known coefficient or function appropriate to the chemistry and flame-holder geometry of the actual system; and ds/dt is to be identified as the local particle velocity, w, which in turn can be equated to $M \,.\, a$. Use may be made of the integral form of equation (2) to reach the following more convenient version of (26)

$$\frac{ds}{dx} \equiv \frac{a_1}{M_1 \,.\, \theta_1} \cdot x M_h^2 \theta \cdot \frac{dQ}{dx} \cdot \frac{dt}{dQ} \quad . \quad (27)$$

whence

$$\frac{M_1 \,.\, \theta_1}{a_1} \,.\, s = \int_1^x x \,.\, M_h^2 \,.\, \theta \,.\, \frac{dQ}{dx} \cdot \frac{dt}{dQ} \,.\, dx \quad . \quad . \quad . \quad . \quad . \quad (28)$$

No general analytical solution can be expected for this expression, owing to the varied possible forms which dQ/dt may assume. However, it remains sufficiently instructive to replace dQ/dt by a simple constant coefficient, k, which will be a measure of the mean time rate of stagnation temperature increase for an elementary carburetted mass, taken over the complete time of the reaction. Using equations relevant to the long flame analysis, and integrating (28) by parts, it may be shown that

$$\frac{M_1 \,.\, \theta_1 \,.\, k}{a_1} \,.\, s = \left[x \,.\, M_h^2 \,.\, \theta \,.\, Q + \frac{1}{\gamma} \int Q \,.\, \theta \,.\, dx \right]_1^x \quad . \quad . \quad . \quad . \quad . \quad (29)$$

A numerical procedure making use of this result is as follows.

(1) Choose values of θ_1, M_1, T_{o1}, q and k; and determine the consistent value of a_1.

(2) For a succession of uniformly spaced x values, apply equations (12) and (18) to tabulate the integrand in (29). For accurate work, a numerical integration may be based on Gregory's method (see Interpolation and Allied Tables (1956)).

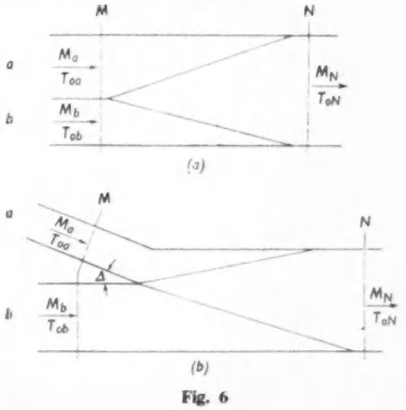

Fig. 6

(3) For each x value, determine all other corresponding magnitudes by the procedure given in the section on Non-Uniform Burning with a Long Flame.

In the case of uniform burning ($\theta_1=1$), there is no longer any advantage in treating x as the independent variable, and the Mach number of the hot stream may be used instead. It may be shown that an exact solution consistent with the terms of equation (29) is :

$$\frac{k.M_1}{a_1(1+\gamma M_1^2)}.s=\frac{T_o}{T_{o1}}.\frac{M^2}{1+\gamma M^2}+\frac{(1+\gamma M_1^2)^2}{M_1^2\left(1+\frac{\gamma-1}{2}M_1^2\right)}\left\{\frac{M^2\left(1+\frac{\gamma-1}{2}M^2\right)}{3\gamma(1+\gamma M^2)^2}+\frac{1+(\gamma-1)M^2}{6\gamma^2(1+\gamma M^2)^2}+\frac{\gamma-1}{6\gamma^2}.\frac{1}{(1+\gamma M^2)}+C\right\} \quad . \quad . \quad . \quad . \quad . \quad (30)$$

This expression is to be used in conjunction with equations (8), (9) and (10). The constant of integration, C, is to be evaluated from the conditions that $M=M_1$, and $T_o=T_{o1}$ at $s=0$. For the case of uniform burning, a treatment of more detailed character has been proposed by Rosen and Hart (1953).

Specimen calculations based on the present treatment are illustrated in Fig. 5, the assumed data being : $\theta_1=2{\cdot}3$; $M_1=0{\cdot}3$; $T_{ob2}/T_{o1}=2{\cdot}7$.

Post-Combustion Mixing of the Hot and Cold Streams

In the simplest case of the mixing of two gas streams "a" and "b" the total cross-sectional area remains constant, and the streams are introduced tangentially to each other, as indicated in Fig. 6 (a); mixing then follows by the agency of either laminar or turbulent diffusion. The spatial effects of such processes have been examined in two-dimensional terms by Pai (1949) and Szablewski (1957), who make the simplifying assumption that static pressure remains constant along the flow axis as well as across it. If, however, an overall assessment of the effects of mixing is sought, inclusive of the pressure changes that will, in fact, occur, a one-dimensional method still has much to commend it; hence, at the downstream plane N shown in Fig. 6 (a), completely uniform distributions of pressure, temperature and particle velocity are assumed. This configuration has bearing upon the theory of jet-driven air ejectors (Kastner and Spooner, 1950) and upon the allied problem of induction wind tunnels (Irving, 1953), which, however, normally involve sonic, or supersonic, velocities for at least one of the streams at approach to the mixing zone. It is therefore emphasised that the present case is confined entirely to sub-sonic flows, the static pressures of the approach streams being necessarily equal.

Employing symbols defined jointly by Fig. 6 (a), and the list of Notation, it may be shown that the principles of continuity of mass, energy and momentum, as applied grossly to the flow between planes M and N, lead to the following main dimensionless results :

$$\psi\frac{T_{ob}}{T_{oN}}+(1-\psi)\frac{T_{oa}}{T_{oN}}=1 \quad . \quad . \quad . \quad (31)$$

$$\sqrt{1-\frac{T_N}{T_{oN}}}=\frac{\beta+\gamma\alpha-\sqrt{(\beta+\gamma\alpha)^2-2(\gamma+1)}}{2\left(\gamma\sqrt{\frac{2}{\gamma-1}}-\sqrt{\frac{\gamma-1}{2}}\right)} \quad . \quad . \quad . \quad . \quad . \quad (32)$$

$$M_N^2=\frac{2}{\gamma-1}\left(\frac{T_{oN}}{T_N}-1\right) \quad . \quad . \quad . \quad . \quad (33)$$

and

$$\frac{P_N}{P_M}=\frac{T_{oN}/T_N}{\sqrt{\frac{2}{\gamma-1}.\left(1-\frac{T_N}{T_{oN}}\right)}}.\frac{1}{\beta} \quad . \quad . \quad . \quad . \quad . \quad (34)$$

Stagnation pressures, if required, may be evaluated from equation (1).

Even for the assumed equalities of specific heats and gas constants between the two streams, the state of flow is defined by no less than four major independent variables ; viz. M_a, M_b, y and ψ ; and consequently a qualitative summary of the effects of mixing cannot be achieved in very brief terms. The parameters α and β, though lacking simple physical significance, are helpful in answering the outstanding question of whether a given mixing flow will be compressive (with deceleration) or expansive (with acceleration); i.e. whether (P_N-P_M) will be positive or negative. It may be shown that the flow is compressive or expansive according, respectively, as

$$\alpha^2>\text{or}<\frac{2}{\gamma-1}(1-\alpha\beta) \quad . \quad . \quad (35)$$

In more detailed terms, general trends exist; though these may occasionally prove misleading. Static pressure changes are trivial, whatever the magnitudes of M_a, M_b and y, if ψ be close to either 0 or 1 ; while maximum changes may be expected to occur in the region of $\psi=0{\cdot}5$. If M_a and M_b are equal, or of comparable magnitudes, expansive flow is likely to follow; while if they are widely disparate, compressive flow will usually result. The following specimen calculations illustrate these latter trends.

M_a	M_b	y	ψ	M_N	P_N/P_M
0·711	0·559	3·132	0·670	0·625	0·955
0·150	0·600	4·000	0·500	0·301	1·052

The above treatment may be applied to the combustion flow models of Fig. 1 by identifying the subscripts "a" and "b" with those of the cold and hot streams, "c" and "h" respectively ; and in such application, the value of ψ will be equal to θ_1. For the assumed flow models, if the overall change of state and motion be calculated for the flow between a plane upstream of combustion and a plane downstream of mixing, it may be verified that such changes will be identical with those which would result from application of equations (8), (9) and (10) for uniform combustion with the same calorific value per pound of total flow. It therefore transpires that, for these models, the post-combustion mixing process must always be expansive and accelerative, and thus of great practical value to the development of a maximum propulsive thrust.

By contrast, for flow systems involving markedly different states for the cold and carburetted streams at approach to the combustion zone, or for systems affected strongly by processes of aerodynamic irreversibility, it is conceivable that a post-combustion mixing of the streams might be compressive, and as such deleterious to thrust performance.

In final comment on the mixing phase of flow, it is important to acknowledge that, in practical systems where compactness is vital, mixing cannot be left solely to such phenomena as laminar or turbulent diffusion. The rate of mixing must therefore be accelerated by introducing the cold dilution air at a slight angle to the combustion gases, so as to create a "penetration" component of momentum. This device is illustrated schematically in Fig. 6 (b) and calls, strictly, for a fresh appraisal of the mixing problem. If both the angle Δ and the overall change of total area are small, equations (31) to (35) should still provide a reasonable description of overall effects; otherwise, a revised treatment becomes necessary, for which a possible mode of attack has been described in another context by Martin (1957).

Conclusions

(1) The methods of one-dimensional gas dynamics are capable of being extended to describe various models of a binary flow system, one stream of which is combustive. Though lacking precision in detail, the "overall effect" theories that evolve have the merit of manageability in numerical work over a wide range of the many variables entailed.

(2) The simplifying assumptions necessarily incurred are qualitatively justifiable in the light of much reported experience, though direct experimental examinations of certain of them remain desirable.

(3) The system behaviour for non-uniform release of heat in a stream is determined broadly by the ratio of flame length to breadth, according as this is relatively large (of an order exceeding unity) or small, approaching zero. In the latter case, major re-arrangements arise in the flow pattern upstream of combustion.

(4) Non-uniform heat release accelerates the whole stream, and increases the Mach numbers in both parts; normally, however, the Mach number of the cold stream at a given station will exceed that of the hot stream.

(5) In most practical circumstances, the process of post-combustion mixing of hot and cold streams is likely to be expansive and accelerative ; and, though thermodynamically irreversible, serves notwithstanding to promote overall plant efficiency and propulsive thrust.

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Alternative Presentations of Pressure-Inferential Metering Formulæ

By T. H. REDDING, M.Sc., F.Inst.P., A.M.I.Mech.E.*

No. I

After consideration of various non-dimensional formulæ which can be derived to effect the explicit determination of flow rate in terms of pressure drop (and vice versa) and the graphical representation and physical significance thereof, attention is given to other forms of representation—i.e. those which are more suitable for designing experiments on throttling devices, for the direct representation of experimental results, and for demonstrating particular characteristics of converging flow. Special attention is given to flow through throttling devices (orifices and nozzles) used for metering purposes. In particular "conventional" flow formulæ (which although of simple algebraic form are explicit in neither the flow rate or the pressure drop) are discussed in the light of general non-dimensional theory, and methods are evolved for using such formulæ for computing flow rate and pressure drop without resort to trial and error (i.e. successive approximation) methods of solution.

THE theoretical treatment of steady flow through enclosed channels of non-uniform section, and, in particular, through pipe-installed orifices and nozzles used for metering purposes is by no means simple. In fact, only in certain cases is it possible to derive, from theoretical considerations alone, equations which relate the wall pressure drop (between specified pairs of upstream and downstream pressure tappings) to the bulk rate of flow with sufficient accuracy to permit their being used as working equations in engineering practice.

Even in these cases—which relate to pressure tappings being taken in regions of sensibly parallel stream lines—the accuracy of the working equation falls short of that demanded of an equation required for use in pressure-inferential metering calculations. Consequently, for the most part, meter design data is based entirely on the results of experimental tests, which themselves, are best correlated in terms of a set of non-dimensional parameters derived by applying Buckingham's π[1, 2, 3] theorem to the basic fundamental equation relating to steady flow through such constrictions, viz.

$$Q = f(p, P, \gamma, \tau_f, E, w, \sigma, P_v, c_p, c_v, D, l_1, l_2, l_3 \ldots)^{\text{I}} \quad \ldots\ldots (1)$$

where

- Q = volumetric bulk rate of flow, reckoned on the fluid density prevailing at the upstream pressure tap.
- p = wall pressure drop between typical upstream and downstream reference sections A_1 and A_2 respectively (see Fig. 1).
- P, γ, τ_f, E, w, σ, P_v, c_p, c_v are, respectively, values of the static pressure, density, viscosity, bulk modulus, specific weight, surface tension, saturated vapour pressure, heat capacity at constant pressure and heat capacity at constant volume—as apply to the conditions prevailing at the upstream pressure tap.
- D = diameter of the main in which the constriction is installed.
- l_1, l_2, l_3 . . . are linear dimensions (other than D), which define the geometry of the constriction.

In a previous paper on this subject[4] the author has shown that such analysis results in a wide choice for the sets of dimensionless variables (each of which is a product of specified powers of two or more of the arguments of equation (1)) which can be used in place of the single-term arguments of equation (1); but in every case the non-dimensional representation ensures that the number of variables is reduced to a minimum (usually four less than in equation (1)) and that the value of each dimensionless argument is independent of the type and size of the units in which the arguments of (1) are measured : furthermore, it provides a means of predicting the performance of a given system from the results of experiments made on other systems in which the values of the various dimensionless parameters are the same as in the original system itself.

As to which of the possible sets of dimensionless variables are most conveniently used in such correlations of experimental data depends on the nature of the problem

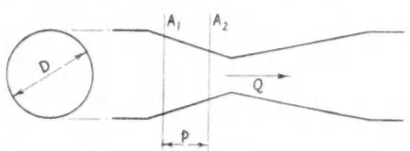

Fig. 1—Definition sketch relating to pipe-convergence

with which the equation is required to deal. Generally, however, we can classify formulæ into two groups : viz. those which are explicit in either Q or p, and those which are not so. Of these, the explicit formulæ are—at least theoretically—the most suitable for computing Q in terms of p and vice versa, but in their simplest form they do not, necessarily, provide the most convenient framework on which to design experiments on flow through throttling devices or serve as the most suitable basis for analytical work which seeks to reveal the (physical) mechanism of the discharge. Furthermore, as will be seen later, cases do arise where (p and Q) non-explicit formulæ are actually more convenient—from the point of view of computing Q in terms of p or vice-versa—than the explicit formulæ appropriate to such calculations.

Explicit Expressions for Q and p

In so far as steady flow is concerned, the author has put forward (loc. cit.) a number of preferred formulæ of the Q- and p-explicit type as relate to cases wherein inertia and viscous forces respectively predominate in determining the pattern of the flow. These formulæ, which cover most cases of converging flow encountered in engineering practice, are as follows :

(1) *Q-Explicit Equations.*—(*a*) when inertia forces are mainly instrumental in determining the pattern of the flow.

$$\frac{\gamma^{\frac{1}{2}}}{p^{\frac{1}{2}}D^2}Q = \eta\left(\frac{1}{p}P, \frac{1}{p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D}\tau_f, \frac{1}{p}E, \frac{D}{p}w, \frac{1}{pD}\sigma, \frac{1}{p}P_v, \frac{c_p}{c_v}, \frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (2)$$

(*b*) when viscous forces are mainly instrumental in determining the pattern of the flow

$$\frac{\tau_f}{pD^2}Q = \eta'\left(\frac{1}{p}P, \frac{pD^2}{\tau_f^2}\gamma, \frac{1}{p}E, \frac{D}{p}w, \frac{1}{pD}\sigma, \frac{1}{p}P_v, \frac{c_p}{c_v}, \frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right)^{\text{II}} \quad \ldots\ldots (3)$$

(2) *p-Explicit Equations.*—(*a*) when inertia forces are mainly instrumental in determining the pattern of the flow

$$\frac{D^4}{Q^{2-\gamma}}p = \phi\left(\frac{D^4}{Q^{2-\gamma}}P, \frac{D}{Q^{2-\gamma}\tau_f}\gamma, \frac{D^4}{Q^{2-\gamma}}E, \frac{D^3}{Q^{2-\gamma}}w, \frac{D^3}{Q^{2-\gamma}}\sigma, \frac{D^4}{Q^{2-\gamma}}P_v, \frac{c_p}{c_v}, \frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (4)$$

(*b*) when viscous forces are mainly instrumental in determining the pattern of the flow

$$\frac{D^2}{Q\tau_f}p = \phi'\left(\frac{D^2}{Q\tau_f}P, \frac{Q}{D\tau_f}\gamma, \frac{D^2}{Q\tau_f}E, \frac{D^4}{Q\tau_f}w, \frac{D^2}{Q\tau_f}\sigma, \frac{D^2}{Q\tau_f}P_v, \frac{c_p}{c_v}, \frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (5)$$

Although equations (2) to (5) are by no means the only Q- and p-explicit formulæ[III] that may be derived as a result of applying the π-theorem to equation (1), certain merits of these representations are apparent, as follows :

(i) Equations appropriate to the flow pattern being determined entirely by the action of inertia forces are determined as limiting cases of (2) and (4), simply by the omission of all dimensionless products which incorporate fluid properties other than the density γ

i.e.

$$\frac{\gamma^{\frac{1}{2}}}{p^{\frac{1}{2}}D^2}Q = \eta_0\left(\frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (2.1)$$

$$\frac{D^4}{Q^{2-\gamma}}p = \phi_0\left(\frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (4.1)$$

(ii) Equations appropriate to the flow pattern being determined entirely by the action of viscous forces are determined as limiting cases of (3) and (5) simply by the omission of all dimensionless products which incorporate fluid properties other than the viscosity τ_f

i.e.

$$\frac{\tau_f}{pD^2}Q = \eta_0'\left(\frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (3.1)$$

$$\frac{D^2}{Q\tau_f}p = \phi_0'\left(\frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D} \ldots\right) \quad \ldots\ldots (5.1)$$

In so far as pipe-installed metering devices (orifices and nozzles) are concerned, installation conditions are usually such that w, σ

* British Scientific Instrument Research Association.

I Absolute or mass-system units, in which the dimensional formulæ of all quantities assume the form (mass)^x (length)^y (time)^z are used throughout this article.

II The primes are used as a mark of distinction and should not be interpreted as indicating the process of differentiation.

III e.g. new Q-explicit equations can be derived from equation (2) by replacing any one of the terms which occur on the right-hand side of equation (2) by the product of this term with any one or more of the terms which occur on this side of the equation.

and P_v are quite ineffective in influencing the pattern of the flow[iv] which is determined either by the action of inertia forces alone, or by the simultaneous action of systems of inertia and viscous forces acting throughout the body of the fluid stream : only in very exceptional cases is the flow to be measured so small as to provide a flow pattern determined by the action of viscous forces alone. Consequently, under such conditions Q- and p-explicit representations of the flow phenomena are most conveniently represented by equations (2) and (4) written in the shortened forms

$$\frac{\gamma^{\frac{1}{2}}}{p^{\frac{1}{2}}D^2}Q = \psi\left(\frac{1}{p}P, \frac{1}{p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D^{r_v}}, \frac{1}{p}E, \frac{c_p}{c_v}, \frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D}\cdots\right) \quad . \quad . \quad . \quad . \quad (2.2)$$

$$\frac{D^4}{Q^{2-r_v}\gamma^{r_v}}p = \phi\left(\frac{D^4}{Q^{2-r_v}\gamma^{r_v}}P, \frac{D}{Q^{\gamma^{r_v}}}, \frac{D^4}{Q^{2-r_v}\gamma^{r_v}}E, \frac{c_p}{c_v}, \frac{l_1}{D}, \frac{l_2}{D}, \frac{l_3}{D}\cdots\right) \quad . \quad . \quad . \quad . \quad (4.2)$$

Certain of the parameters in these equations are, however, proportional to well-established flow criteria (or to the reciprocals or powers thereof). Thus, if : α = the (velocity-of-approach inclusive) flow coefficient of the throttling device, as conventionally defined by the equation

$$\alpha = \frac{Q}{\left(\frac{\pi}{4}D^2\right)m\sqrt{2p/\gamma}} \quad . \quad . \quad . \quad . \quad (6)$$

(where $m=l_1^2/D^2$ (say) is the maximum channel area-reduction ratio occurring in the throttling device); $x=c_p/c_v$; and R and M are the Reynolds and Mach numbers of the flow respectively (as defined with respect to the pipe diameter D and the corresponding bulk velocity $V=4Q/\pi D^2$) we have :

$$R = \frac{V\gamma D}{r_v} = \frac{4}{\pi}\frac{Q\gamma}{Dr_v} \quad . \quad . \quad . \quad . \quad (7)$$

$$M = V/V_s$$

(where V_s is the velocity of sound relevant to the conditions of temperature and pressure in the non-contracted main), so that

$$M = V\sqrt{\gamma/E} = \frac{4}{\pi}\left(\frac{Q^{2-r_v}\gamma^{r_v}}{D^4E}\right)^{\frac{1}{2}} \quad . \quad . \quad (8)$$

It is therefore apparent that $\gamma^{\frac{1}{2}}Q/p^{\frac{1}{2}}D^2 \propto m\alpha$, $l_1/D \propto m^{\frac{1}{2}}$, $P/p \propto (p/P)^{-1}$, $Dr_v/Q\gamma \propto 1/R$ and $D^4E/Q^{2-r_v}\gamma^{r_v} \propto M^{-1}$. In consequence, equations (2·2) and (4·2) can be written in the forms

$$\alpha = \psi\left(m, \frac{p}{P}, \frac{1}{p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D^{r_v}}, \frac{1}{p}E, x, \frac{l_2}{D}, \frac{l_3}{D}\cdots\right) \quad . \quad (2.3)$$

$$\alpha = \phi\left(m, \frac{D^4}{Q^{2-r_v}\gamma^{r_v}}P, R, M, x, \frac{l_2}{D}, \frac{l_3}{D}\cdots\right) \quad . \quad (4.3)$$

If now, we confine our attention to the flow of gases and assume—as is reasonable—that flow within the throttle takes place isentropically and adiabatically, $E=Px$ so that (2·3) and (2·4) reduce to

$$\alpha = \psi\left(m, \frac{1}{p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D^{r_v}}, \frac{p}{P}, x, \frac{l_2}{D}, \frac{l_3}{D}\cdots\right) \quad . \quad (2.4)$$

$$\alpha = \phi\left(m, R, M, x, \frac{l_2}{D}, \frac{l_3}{D}\cdots\right) \quad . \quad . \quad . \quad (4.4)$$

It should be particularly noted that dimensional analysis alone cannot provide information regarding the forms of equations (2·4) and (4·4), information regarding which can only be obtained by reference to experiments. [However, an excepting case occurs when only one parameter, π_r, say, is involved, since in such cases equations (2·4) and (4·4) reduce to the form π_r=constant—e.g. when dealing with geometrically similar systems in which the flow pattern is influenced only by the fluid density, equation (4·4) reduces to the form α=constant, i.e. $Q^2 \propto (D^4/\gamma).p$.] Thus, experiment shows that, in the case of air flow through corner-tapped sharp edged metering orifices having an area reduction ratio $m=0{\cdot}63$, equations (4·4) and (2·4) can be represented by the series of curves shown in Figs. 2 and 3 in which α is plotted as a function of R for constant (selected) values of M, and as a function of $r_v/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ for constant (selected) values of p/P respectively.

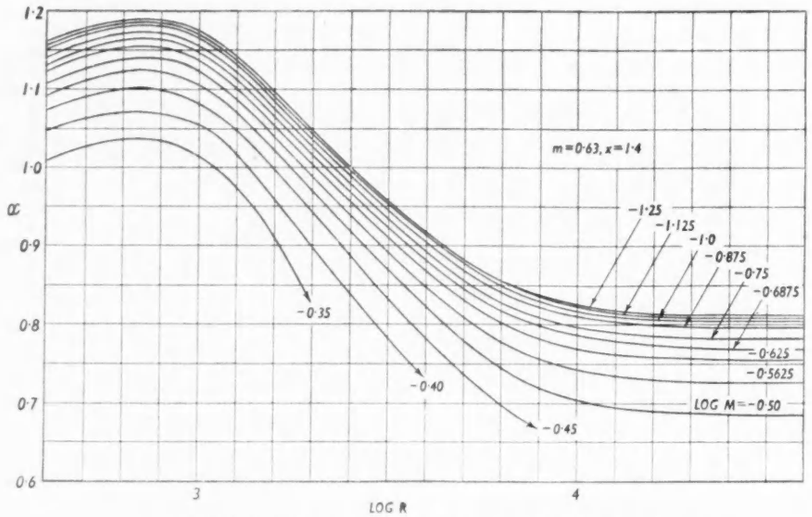

Fig. 2—Sharp-edged orifice ($m=0{\cdot}63$) : α as a function of log R and log M

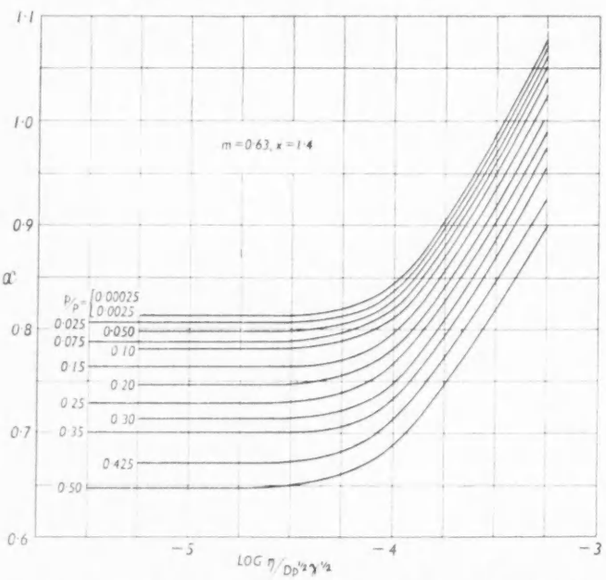

Fig. 3—Sharp-edged orifice ($m=0{\cdot}63$) : α as a function of log $r_v/Dp^{\frac{1}{2}}\gamma^{\frac{1}{2}}$ and p/P

[In the absence of long range experimental data, these curves—given here *for purposes of illustration*—are the result of a calculation which combines Johansen's[5] results on long-range experiments with liquids and I.S.A.[6, 7] recommendations regarding the manner in which compressibility should be taken into account when sharp-edged orifices are used to measure within the Reynolds number range $R>10{,}000$. The curves should not therefore be regarded as accurately representing the long range characteristics of any particular orifice-form but rather as being illustrative of the probable general long-range form of the Q- and p-explicit characteristics of sharp-edged orifices. Again, a comparatively high area ratio ($m=0{\cdot}63$) has been chosen for the purposes of this illustration, since the effect of viscosity is most marked at higher values of the area reduction. At lower values of m the curves retain the same general form but with the peak (shown in Fig. 2 but outside the range of values of $r_v/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ shown in Fig. 3) becoming less pronounced and moving towards the axis of α as the area ratio tends towards zero. (The fact that a "peak" occurs at all, is a consequence of decreasing Reynolds number having the effect of simultaneously decreasing the degree of jet contraction and increasing the friction loss coefficient—these being tendencies which are opposite in their effect on the flow coefficient. Thus, with decreasing Reynolds number the effect of reduced jet contraction is initially the most effective factor and α tends to increase: subsequently, however, the effect of increasing frictional loss coefficient becomes the most effective factor—so establishing, first, a stationary, and thereafter an overall lowering in the value of α.) Curves appropriate to nozzle flow are of the same general form as Figs. 2 and 3 except that, in the absence of jet contraction, no peak value of α occurs in the lower Reynolds number range.]

Examination of Figs. 2 and 3 reveals at once certain well-defined regions within which the flow pattern is characterised by its being independent of one or more of the parameters that (otherwise) control it. Thus, (*a*) at Reynolds numbers in excess of 19950 ($\log R>4{\cdot}3$) α is sensibly a function of M alone, (*b*) at Mach numbers less than 0·056 ($\log M<-1{\cdot}25$) α is sensibly a function of

[iv] This follows, since in most installations the difference in level of the pressure tappings is insignificant, the constriction is situated some distance from points where surface tension forces are operative (e.g. at inlet and outlet extremities of the main), and the static pressure at all points in the stream (when the flowing fluid is a liquid) is well above that of the relevant saturated vapour pressure.

[v] α here corresponds to the coefficient designated by α' in reference 4.

R alone, (*c*) at values of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ less than approximately 0·00003162[vi] (log $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ —4·5) α is sensibly a function of p/P alone and (*d*) at values of p/P less than 0·0025 α is sensibly a function of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ alone. (Conditions (*a*) and (*b*) are apparent on reference to Fig. 2, whilst (*c*) and (*d*) follow from Fig. 3.) Furthermore, for values of R and M simultaneously in excess of 19950 and less than 0·056 α is independent of both R and M, whilst for values of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ and p/P simultaneously less than 0·00003162 (approximately) and 0·0025 α is independent of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ and p/P. Also of interest is the fact that in the case of Fig. 2, the characteristic α versus R for liquids very closely approximates (to within 0·3 per cent) to the gas curve appertaining to $M=0·056$ over the whole range of Reynolds numbers shown. Similarly, in the case of Fig. 3, the characteristic α versus log $\tau_i/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ for liquids is sensibly the same as that shown for $p/P=0·0025$ for air.

The physical significance of the above remarks is that in cases (*a*) and (*c*) the flow pattern is determined by the interaction of inertia and elastic forces and in (*b*) and (*d*) by the interaction of inertia and viscous forces acting throughout the body of the fluid stream. Moreover, in those zones where α is independent of both R and M or of both $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ and p/P the flow pattern is determined entirely by the action of inertia forces—i.e. by virtue of forces which result from the fluid having the property of mass concentration, as measured in practice by the density function. Except in regions of very low Reynolds numbers (mentioned below) the pattern of the flow in zones other than those determined by (*a*), (*b*), (*c*) and (*d*) is determined by the interaction of inertia, viscous, and elastic forces acting throughout the body of the fluid stream.

Extension of Fig. 2 to cover values of R less than 398·1 (log $R<2·6$) (the lower limit of R shown in Fig. 2) shows that, at very low Reynolds numbers and at low values of M (i.e. $R<20$ with $M<0·0176$) α becomes sensibly proportional to $R^{\frac{1}{2}}$: similarly, if Fig. 3 is continued to include values of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ greater than 0·0005623 (log $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D>-3·25$) (the upper limit of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ shown in Fig. 3) the curve relating to $p/P\leqslant 0·0025$ proceeds to a peak value and thereafter tends to a form appropriate to α being proportional to $(\tau_i/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D)^{-1}$. Again, these results are in agreement with the physics of the problem—since at very low Reynolds numbers and low values of p/P viscous forces are so large compared with those due to inertia and fluid elasticity that these latter have but negligible effect on the pattern of the flow. Under these circumstances the Q- and p-explicit flow characteristics are represented by equations (3) or (5) in the form appropriate to their special application to the isentropic adiabatic flow of gases when reduced to the limiting case of E and γ being ineffective in influencing the pattern of the flow,

i.e. by

$$\frac{\tau_i}{pD^3}Q=\theta\left(m, x, \frac{l_2}{D}, \frac{l_3}{D}\ldots\right) \quad . \quad . \quad (3.1)$$

when, for a given value of x and geometrically similar flow paths (which implies a common value of the area reduction ratio m)

$$\frac{\tau_i}{pD^3}Q=\text{constant} \quad . \quad . \quad . \quad . \quad (3.2)$$

[vi] More precisely, α is sensibly a function of p/P alone for values of $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ less than $(\tau_i/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D)_0$, where $(\tau_i/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D)_0$ varies over the range 0·00003981 to 0·00002512 (log $\tau_i/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D=-4·4$ to $-4·6$) as p/P increases from zero to 0·5.

Also from (6) and (7) we have:

$$\frac{\alpha^2}{R}\propto\frac{Q\tau_i}{pD^3} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

and

$$\alpha\cdot\frac{\tau_i}{p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D}\propto\frac{Q\tau_i}{pD^3} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

—which together with 3·2 give the relations

$$\alpha\propto R^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and

$$\alpha\propto(\tau_i/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D)^{-1} \quad . \quad . \quad . \quad (12)$$

For given values of τ_i and D we can substitute for α and R (according to the relations $\alpha\propto Q\gamma^{\frac{1}{2}}/p^{\frac{1}{2}}D^2$ and $R\propto Q\gamma/D\tau_i$—as follow from equations (6) and (7)) in either equations (11) or (12) to give

$$Q\propto p \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

It is interesting to compare this result with the other extreme case which occurs when the flow pattern is determined entirely by the action of inertia forces—i.e. in regions of simultaneously high values R and low values of M, or of low values of both $\tau_i p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ and p/P. In this case the Q- or p-explicit equation relating to a constant value of x and geometrical similar flow paths is obtained as a limiting case of equation (2·4) (or (4·4)), i.e. as

$$\alpha=\text{constant} \quad . \quad . \quad . \quad . \quad (14)$$

when for given values of D,

$$Q\propto p^{\frac{1}{2}}\gamma^{-\frac{1}{2}} \quad . \quad . \quad . \quad . \quad (15)$$

Observational Formulæ

Although the previously discussed methods of presenting the results of experiments are very convenient for the purpose of computing Q in terms of p, or vice versa, and for illustrating the physical principles underlying flow through channel convergences, they do not, in general, provide a suitable framework for the recording of experimental data in the first instance—i.e. for the numerical representation of those actual sequences of operations which serve to establish the phenomena and which, after suitable transformation, result in the particular Q- or p-explicit dimensionless representations discussed above.

Thus, used as a method of representing primary experiments on geometrically similar systems (at a given value of x), equation (4·4)—as appropriate to the isentropic adiabatic flow of gases—would involve plotting either :

(*a*) Corresponding values of α and R at constant (selected) values of M, i.e.

$$\frac{4}{\sqrt{2.\pi m}}\left(\frac{Q\gamma^{\frac{1}{2}}}{p^{\frac{1}{2}}D^2}\right) \text{ versus } \frac{4}{\pi}\left(\frac{Q\gamma}{D\tau_i}\right)$$

at selected values of $\frac{4}{\pi}\left(\frac{Q^2\gamma}{D^4P_X}\right)^{\frac{1}{2}}$

(*b*) Corresponding values of α and M at constant (selected) values of R, i.e.

$$\frac{4}{\sqrt{2.\pi m}}\left(\frac{Q\gamma^{\frac{1}{2}}}{p^{\frac{1}{2}}D^2}\right) \text{ versus } \frac{4}{\pi}\left(\frac{Q^2\gamma}{D^4P_X}\right)^{\frac{1}{2}}$$

at selected values of $\frac{4}{\pi}\left(\frac{Q\gamma}{D\tau_i}\right)$

(*c*) Corresponding values of R and M at constant (selected) values of α, i.e.

$$\frac{4}{\pi}\left(\frac{Q\gamma}{D\tau_i}\right) \text{ versus } \frac{4}{\pi}\left(\frac{Q^2\gamma}{D^4P_X}\right)^{\frac{1}{2}}$$

at selected values of $\frac{4}{\sqrt{2.\pi m}}\left(\frac{Q\gamma^{\frac{1}{2}}}{p^{\frac{1}{2}}D^2}\right)$

Under conditions of constant temperature,[vii] and for a given value of D, this amounts to observing simultaneous values of p, Q and P when the system is variously adjusted to ensure a (given) constant value of $Q^2\gamma/D^4Px$ or of $Q\gamma/D\tau_i$ or of $Q\gamma^{\frac{1}{2}}/p^{\frac{1}{2}}D^2$ as the case may be. Even if τ_i is independent of P, and the pressure-volume-temperature relationship for the fluid is known (so that γ can be computed from a knowledge of P without resort to actual determinations of fluid density), the adjustment of a flow system to effect constant values of $Q^2\gamma/D^4Px$ or of $Q\gamma^{\frac{1}{2}}/p^{\frac{1}{2}}D^2$ or even of $Q\gamma/D\tau_i$ is no easy matter, since this cannot be effected by merely regulating one of the variables P, Q and p to a constant value. Similar consideration of formula (2·4) shows that, it, too, fails to yield convenient formulæ for the representation of primary experiments.

It is, therefore, opportune to seek a non-dimensional representation of the phenomena in which one of the variables, P, Q or p[viii] occurs in one only of the dimension-

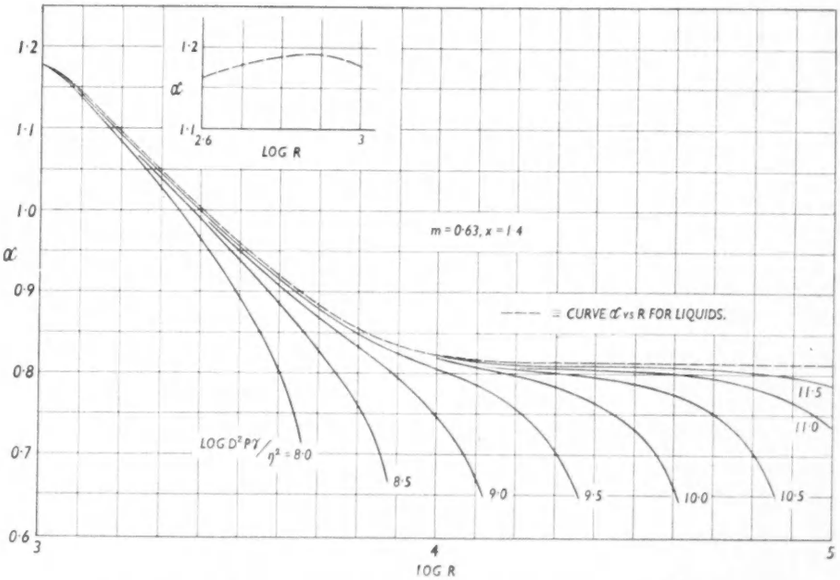

Fig. 4—Sharp-edged orifice ($m=0·63$) : α as a function of log R and log $D^2P\gamma/\tau_i^2$

[vii] i.e. when both γ and τ_i are functions only of the pressure.

[viii] Of these quantities, P is, by far, the easiest to regulate to a constant value P_0 (say).

less groups, and even then (within this group) not in combination with either of the other two. Under these circumstances it would only be necessary to regulate *one* parameter to a constant value and to observe, simultaneously, values of the other two. Bearing in mind that any term in equation (4·4) can be replaced by the product of this term (or power thereof) with any one or more of the remaining terms (or powers thereof) which occur in this equation, it is apparent that a relation satisfying the above condition—and involving P as the variable to be localised in one non-dimensional group—may be obtained by replacing the term M in equation (4·4) by $M^{-2}R^2x^{-1} \propto D^2P\gamma/\tau^2$ to give the (p-explicit) equation

$$\alpha = \phi_{(Re)}\left(R, \frac{D^2P\gamma}{\tau^2}\right) \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Alternatively, we might have replaced M and R in equation (4·4) by $M^{-2}R^2x^{-1} \propto D^2P\gamma/\tau^2$ and $\alpha R^{-1} \propto \tau/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ to give the (Q-explicit) equation

$$\alpha = \theta_{(Re)}\left(\frac{\tau}{p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D}, \frac{D^2P\gamma}{\tau^2}\right) \quad . \quad . \quad . \quad . \quad (17)$$

Finally, we can replace $\tau/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D$ in equation (17) by $(\tau/p^{\frac{1}{2}}\gamma^{\frac{1}{2}}D)^2(\gamma PD^2/\tau^2) \propto P/p$ to give the (Q-explicit) equation

$$\alpha = \theta_{(Re)}\left(\frac{p}{P}, \frac{D^2P\gamma}{\tau^2}\right) \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Whilst any of the above formulæ provide a suitable basis on which to design basic experiments on flow through throttling devices, equation (16) is, perhaps, the most (generally) convenient in view of its containing the conventional (pipe) Reynolds number R: the equation was in fact first used by Hodgson[8] (with the slight modification that a coefficient $\alpha' = (1-m^2)^{\frac{1}{2}} \cdot \alpha$ was used instead of α) in his original calibrations of sharp (square) edged metering orifices. The general form of this characteristic, as it applies to air flowing through a corner tapped sharp-edged orifice plate of area ratio $m = 0{\cdot}63$, is shown in Fig. 4. (As with Figs. 2 and 3, these curves are drawn for purposes of illustration only, having been computed from Johansen's data on incompressible flow and I.S.A. recommendations for taking fluid compressibility into account.) Also shown, on the same diagram, is the characteristic α versus R for liquids, from which it appears that, as $D^2P\gamma/\tau^2$ increases, the gas curve tends to become sensibly identical with the liquid curve over ever-increasing ranges of the Reynolds number.

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(To be concluded)

Interferometric Measurement of the Straightness of Plug Gauges*

By F. R. TOLMON

An apparatus is described which offers a ready means of assessing the straightness of precision plug gauges and, in addition, provides a precise method for measuring the actual errors from straightness to the order of one millionth of an inch.

THE accuracy of measurement of the diameter of parallel plug gauges is limited by the quality of the plug itself, one important factor being variation in the diameter of the plug along its length due to lack of straightness of the generators. Thus, if it is desired to measure the diameter to one millionth of an inch, it is also necessary to develop a method for measuring the straightness to a similar order of accuracy. The interferometric method described here will achieve this precision for individual generators in turn and will also provide a rapid visual examination for assessing plugs which are more than ten millionths out of straight over their total length.

The apparatus, shown diagrammatically in two views in Fig. 1, consists of a Fizeau type interferometer and a microscope with a micrometer controlled graticule for viewing and measuring the fringes. Interference fringes are produced, in mercury green illumination, by reflection from the cylindrical surface of the plug and the lower surface of an adjustable optical flat which is coated with bismuth oxide. The fringes are viewed at a magnification of fifty times through a microscope mounted on a horizontal slide which provides sufficient movement parallel to the axis of the plug to scan the whole length of the generator under test.

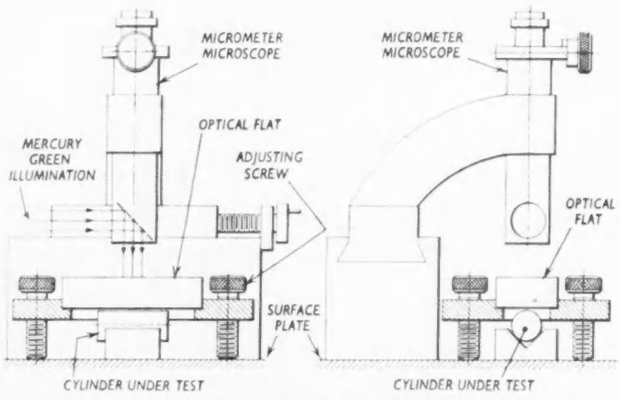


Fig. 1—Arrangement of apparatus for interferometric measurement of the straightness of plug gauges

In operation, the plug gauge is placed in a vee block with its axis horizontal and the inclination of the optical flat is adjusted, by means of the three adjusting screws, until the lower surface of the flat is parallel to, but just clear of, the cylindrical surface of the plug. In this condition, fringes are formed parallel to the axis of the plug and symmetrically disposed on either side of the upper-

* Communication from the National Physical Laboratory.

TABLE I

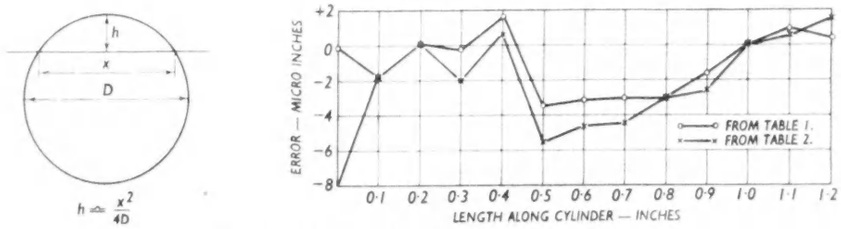
Positions along plug (inches)	Microscope readings (microns)		x (microns)	x^2	h* (10^{-6}in)	Errors from straightness, with two points forced to (0) (microinches)
	Left-hand fringe	Right-hand fringe				
0	555	431	124	15,376	0·809	−0·2
0·1	553	444	109	11,881	0·625	−2·1
0·2	569	443	126	15,876	0·836	(0)
0·3	574	450	124	15,376	0·809	−0·3
0·4	589	450	139	19,321	1·017	−1·7
0·5	574	475	99	9,801	0·516	+3·3
0·6	582	479	103	10,609	0·558	+2·9
0·7	586	484	102	10,404	0·548	+3·0
0·8	590	490	100	10,000	0·526	+3·3
0·9	603	491	112	12,544	0·660	+2·0
1·0	616	488	128	16,384	0·862	(0)
1·1	627	489	138	19,044	1·000	−1·3
1·2	625	495	130	16,900	0·889	−0·2

* $h = \frac{x^2}{4D} = \frac{x^2}{4 \times 19{,}000}$ microns $= \frac{x^2}{19{,}000} \times 10^{-6}$in.

TABLE II

Positions along plug (inches)	Microscope readings (microns)		x (microns)	x^2	h* (10^{-6}in)	Errors from straightness, with two points forced to (0) (microinches)
	Left-hand fringe	Right-hand fringe				
0	1,062	985	77	5,929	0·312	−8·1
0·1	1,061	935	126	15,876	0·836	−2·0
0·2	1,039	905	134	17,956	0·945	(0)
0·3	1,002	893	109	11,881	0·625	−2·3
0·4	984	861	123	15,129	0·796	+0·3
0·5	926	875	51	2,601	0·137	−5·5
0·6	897	849	48	2,304	0·121	−4·7
0·7	866	831	35	1,225	0·064	−4·4
0·8	845	797	48	2,304	0·121	−3·0
0·9	817	776	41	1,681	0·088	−2·4
1·0	805	737	68	4,624	0·243	(0)
1·1	775	717	58	3,364	0·177	−0·2
1·2	761	696	65	4,225	0·222	+1·5

* $h = \frac{x^2}{4D} = \frac{x^2}{4 \times 19{,}000}$ microns $= \frac{x^2}{19{,}000} \times 10^{-6}$in.



Figs. 2 and 3—Errors in straightness of a plug gauge

most generator. The position of the vee block is initially located and fixed so as to define an axis in the plane of the optical axis of the microscope and parallel to the traverse motion of the microscope. The centre of the fringe pattern is thus maintained in the centre of the field of view of the microscope.

The first-order fringe on each side of the uppermost generator defines the straightness of this generator and any deviations from straightness are revealed by a variation in the spatial separation of these two fringes. A very rapid test is therefore available for determining that the generator in view is straight within 11 microinches† by traversing the microscope from one end of the cylinder to the other and noting that the two first-order fringes do not meet at any position along the length of the plug. This is the case when the first-order fringes have their widest separation, which is the condition normally achieved when setting up.

If the plug satisfies this visual inspection, the errors in straightness may then be assessed from the separation of the two fringes which are measured at known intervals along the length of the plug by means of the micrometer controlled graticule in the microscope. Because the two fringes define a plane parallel to the lower surface of the optical flat, the parameter h (see Fig. 2) defines the height of the uppermost generator above this plane at each measured position. If the separation at one position is x, as shown in Fig. 2, the corresponding value for h can be calculated from the formula :

$$h(D-h) = \left(\frac{x}{2}\right)^2$$

$$\text{or } h = \frac{1}{D}\left[\frac{x^2}{4} - h^2\right]$$

or, with sufficient accuracy,

$$h = \frac{x^2}{4D}.$$

Successive values for h at equal intervals along the length of the plug may be plotted to show the errors of straightness.

Two independent tests have been carried out at 0·1in intervals along different generators of a plug $\frac{3}{4}$in (19mm) diameter and 1·2in (30mm) long, and the results obtained, together with the necessary calculations, are shown in Tables I and II. In order to facilitate comparison of the results obtained on the two generators, the results have been adjusted to give zero values at the observation points 0·2in from each end of the plug. From the graphical representation of the results in Fig. 3 it can be seen that the straightness of the two generators is closely similar, except for the run-off at one end, and that each exhibits the same characteristic.

To obtain an appreciation of the sensitivity of the method and of the accuracy possible, the formula for h can be differentiated. Thus :

$$dh = \frac{2 \times dx}{4D}$$

or

$$\frac{dx}{dh} = \frac{2D}{x}$$

To obtain an accuracy of 1 microinch in the measurement of h for the $\frac{3}{4}$in diameter plug used, when the separation of the fringes is, say, 140 microns or 0·005 6in (c.f. column 4 in the Tables), the micrometer measurement must be made to an accuracy dx, where

$$dx = \frac{0{\cdot}000\ 001}{0{\cdot}005\ 6} \times \frac{3}{2} \text{ in}$$

$$= 0{\cdot}000\ 3\text{in}$$

This accuracy of measurement of x is readily obtained at fifty times magnification. For smaller values of x the sensitivity is greater, but the fringes become less well defined.

The work described above has been carried out as part of the research programme of the National Physical Laboratory and this paper is published by permission of the Director of the Laboratory.

† Actually 10·8 microinches, half the wavelength of the green mercury line used.

The Yard and the Pound (Avoirdupois) for Science and Technology

THE Directors of the following standards laboratories, Applied Physics Division, National Research Council, Ottawa, Canada ; Dominion Physical Laboratory, Lower Hutt, New Zealand ; National Bureau of Standards, Washington, United States ; National Physical Laboratory, Teddington, United Kingdom ; National Physical Research Laboratory, Pretoria, South Africa ; and the National Standards Laboratory, Sydney, Australia, have discussed the existing differences between the values assigned to the yard and to the pound in different countries. To secure identical values for each of these units in precise measurements for science and technology, it has been agreed to adopt an international yard and an international pound having the following definitions :

The international yard equals 0·9144 metre ; the international pound equals 0·453 592 37 kg.

It has also been agreed that, unless otherwise required, all non-metric calibrations carried out by the above laboratories for science and technology on and after July 1, 1959, will be made in terms of the international units as defined above or their multiples or submultiples.

The new international units conform with the recommendations of the Board of Trade Departmental Committee on Weights and Measures Legislation (the " Hodgson Committee ") but the Board of Trade points out that the units will have no statutory force in the United Kingdom and may not be used for trade purposes in this country. The yard and pound units to be used in trade are the imperial units laid down in the Weights and Measures Act, 1878.

The values of the yard currently in use in the British Commonwealth and the United States of America are as follows when expressed in terms of the metre :

1 imperial standard yard	= 0·914 397 2m
1 Canadian yard	= 0·9144m
1 yard as at present used by the National Physical Laboratory for science and technology, based on the 1922 value of the imperial standard yard	= 0·914 398 41m
1 United States yard	= 0·914 401 83m

As the imperial standard yard is about 5 parts per million (0·0002in) less than the United States yard (which is defined in terms of the metre) and is shortening at the rate of over one-millionth of an inch per annum, the consequent discrepancies in measurements of length are important in modern precision engineering. To give two examples, it is necessary to know the lengths of the highest grade block gauges accurately to one part per million, and the permissible error on accurate yard scales is 0·0001in. Though the N.P.L., by using the metre and wavelengths of light and by adopting the 1922 value of the imperial standard yard in relation to the metre, has been able to stabilise its basis of reference for length measurements in terms of the yard and its common submultiples for science and technology, unification of the yard standard for these purposes in the British Commonwealth and the United States can no longer be delayed.

With regard to the pound, the values currently in use when expressed in terms of the kilogramme are :

1 imperial standard pound	= 0·453 592 338kg
1 Canadian pound	= 0·453 592 43kg
1 United States pound	= 0·453 592 4277kg

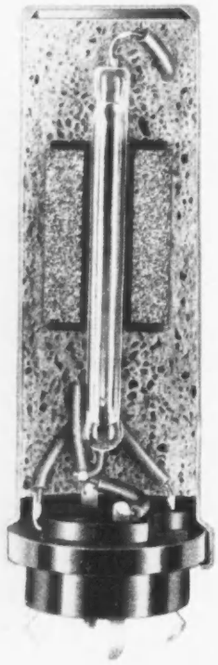
There is evidence that the imperial standard pound has diminished by about seven parts in 10,000,000 since 1846. It is about two parts in 10,000,000 (0·0014 grain) smaller than the United States and Canadian pounds, which are defined in terms of the very closely safeguarded international prototype kilogramme. Though the discrepancy between the pounds is not at present causing any technical difficulty the co-existence of independently defined pounds is unsatisfactory in science and technology.

The agreed international values of the yard and the pound fall between the existing United States and British units, and the international yard, which is the same as the Canadian yard, accords exactly with the relationship 1in = 25·4mm, which is already extensively used in this country and abroad for approximate conversions. The adoption of the international values of the yard and the pound will be of particular benefit to all those concerned with accurate measurements of length and mass for scientific and technological purposes in the British Commonwealth and the United States.

Physical Society Exhibition

There was held from Monday to Thursday last, in the Halls of the Royal Horticultural Society, the forty-third annual exhibition of the Physical Society. There were displayed and demonstrated large numbers of devices and techniques, of which we describe below a few of those of interest to the engineer.

THE forty-third Physical Society Exhibition was opened on Monday, January 19, by Sir Cyril Hinshelwood, F.R.S., President of the Royal Society. During the four days



The glass sealed reed relay switch assembled in a can

the exhibition continued there was given a series of discourses, on Monday on "The Physics of Controlled Thermonuclear Fusion," by Mr. R. S. Pease; on Tuesday on "Frontiers of Space Research," by Dr. Robert M. Page (U.S. Naval Research Laboratory, Washington), and on Wednesday on "Physical Science in the Trans-Antarctic Exhibition," introduced by Sir Vivian E. Fuchs and delivered by Mr. J. G. D. Pratt. Whereas the exhibition is normally devoid of foreign instruments, one stand this year was occupied by Swedish exhibits selected by the Royal Swedish Academy of Engineering Sciences; many of the instruments included were lettered in English, and others were of English manufacture.

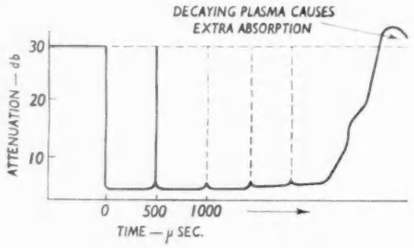
We are advised by the Physical Society that the research taking place in this country to-day is "virile."

There were to be seen a large variety of unconventional electric switches, of which we illustrate one shown by the Plessey Company, Ltd. This is a reed relay sealed into a glass tube: the two reeds overlap slightly at the midpoint of a solenoid surrounding the tube, so that when the solenoid is energised the reeds are drawn together magnetically. Rhodium-plated contact surfaces are provided, and the standard version with dry air in the tube will switch 0·5A at 50V d.c. non-inductive, with a tentative life of 200×10^6 operations: the resistance when open is 10^{11} ohms at 500V d.c. The relay is stable until the reeds enter resonance at 800 c/s. High-voltage operation and heavy contact ratings can be achieved by using evacuated tubes. By use of a permanent magnet to bias the switch to "make," the relay can be given a polarised break action. Relays are available both unwound and complete, resiliently mounted in an aluminium can for mounting on a printed circuit, as illustrated.

Among the demonstrations performed by Mullard, Ltd., was one of a hollow-cathode glow discharge tube which exhibits a stable negative impedance characteristic over a range of current values and provides a small amount of audio gain. The tube, which is similar to one developed by the Bell Telephone Laboratories, produces very little noise or distortion and may be used for switching the speech circuits of a telephone network. The demonstration illustrated the gain given by the negative impedance by comparing the signals obtained with the tube in and out of circuit. This was described as a research item.

The Research Laboratories of The General Electric Company, Ltd., displayed a switch functioning at microwave frequencies. The device shown was intended to switch signals in the 1000 to 4000 Mc/s frequency range from one route to another in less than 1 millisecond.

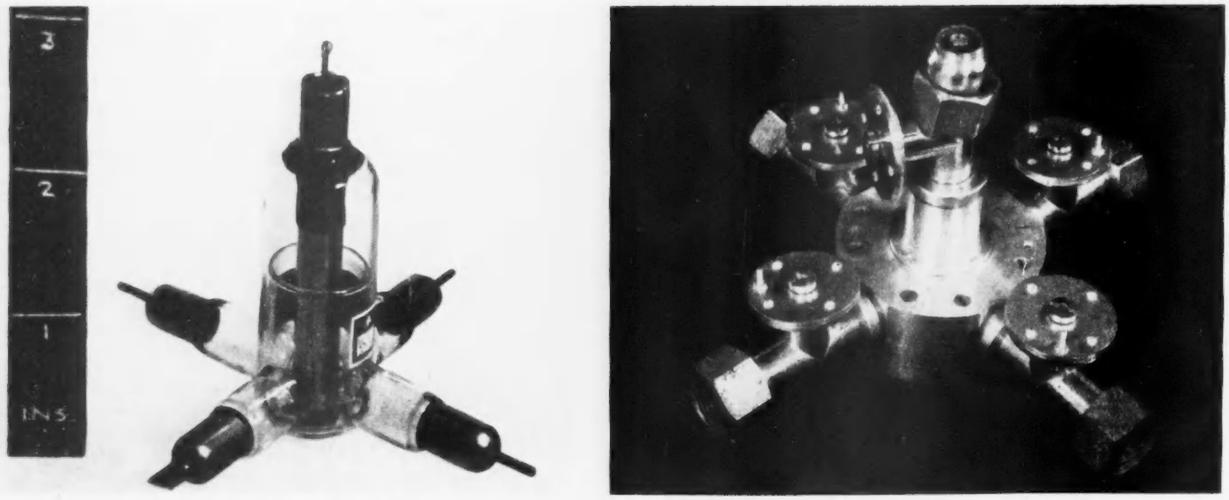
Consider an air-spaced coaxial line, then if the inner is broken the line acts as a cut-off



Valve under successive pulsing

attenuator, and if the gap is increased the attenuation is also increased. If there is a glass tube having the same bore dimensions as the inner in the space and it is arranged that we can strike a gas discharge in the tube, then when the electron density in the discharge is greater than a critical density, the discharge acts as a good conductor for low power signals of all frequencies below a critical frequency (called the "plasma" frequency). The switch is thus "on." If the discharge is switched off then the electron density decays below the critical value in about a millisecond and the switch is "off."

A continuous d.c. discharge, however, produces a contribution of noise which would be added to the signal switched. It is therefore arranged to initiate the discharge by applying a d.c. pulse of 2 to 4 microseconds duration, and to allow the discharge to decay. When the electron density has reached the level where it is starting to cause attenuation, the d.c. discharge is pulsed again. As the noise only occurs during the



The valve of the four-way microwave switch is seen (left) removed from the complete assembly (right). The four flat flanges belong to the radio-frequency by-pass

pulses relatively little noise is produced. In practice this noise could be gated out in a receiver. The sort of propagation obtained in practice is shown in the accompanying diagram.

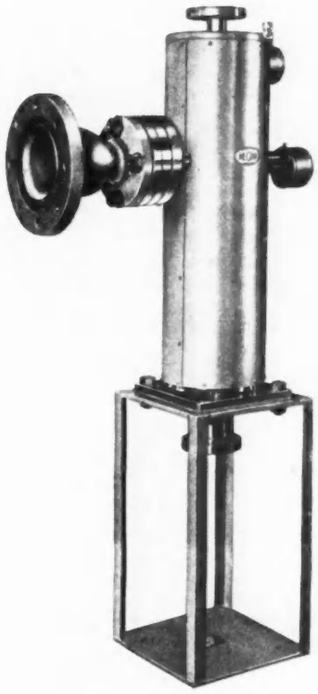
Turning to the four-way switch (illustrated) the inner is terminated in a cathode which can act as the negative electrode for a discharge in any of four directions. By pulsing any of the four anodes a conducting path is struck to any of the channels. If this is pulsed repetitively, say, every 500 μsec, a conducting channel with a small loss is maintained. When it is desired to switch to another channel, time must first be allowed for the decay of the first gas discharge before striking the next : the time to be allowed is rather less than 1 millisecond.

The glass discharge tube contains an oxide-coated cathode and is filled with a rare gas, e.g. krypton or xenon, which must be extremely pure if good performance is to be obtained. The pressure is low so that the frequency of collision of the gas molecules is small compared with the frequency of the radio-frequency signal. The glass tube fits into a five-arm junction in 50-ohm, $\frac{7}{8}$in coaxial line. Suitable stubs are arranged for bringing out the d.c. connections without causing appreciable reflection.

Another G.E.C. demonstration which appears to have great potential interest was devoted to impermeable graphite. It is well known that graphite can be rendered impermeable by impregnation with organic compounds, and there were displayed elsewhere in the exhibition examples treated with polymerised furfuryl alcohol and with gaseous hydrocarbons. An impregnated tube at about 600 deg. Cent. was demonstrated holding a head of about 1 atmosphere with a leakage of 1usec magnitude. To over-ride the temperature limitations of treated graphite components, and at the same time secure extreme impermeability, G.E.C. has evolved a process in which the graphite is formed in an impermeable state. This state is referred to as completely impermeable, and it is anticipated that the material will be suitable as a canning material for reactor fuel elements. We are advised that the process of forming the graphite does not need supervision beyond industrial standards, that inspection techniques are reliable, and that the reject rate is not intolerable. It should be noted that, provided that the assembly design has been based on adequate knowledge of coefficients of thermal expansion, the graphite components can satisfactorily be bonded to metal by a relatively low-temperature process.

Another item of equipment with an application to nuclear power plant was displayed by the Baker Platinum Division of Engelhard Industries, Ltd. The neutron irradiation of both light and heavy water causes splitting of the molecule with formation of the so-called radiolytic gas. In the majority of applications it is essential, for reasons of safe operation and economy, that this radiolytic gas is recombined to form water. The catalytic recombination unit shown makes use of a supported platinum group metal catalyst to promote this reaction at room temperature and above. A unit of this kind is used on the United Kingdom Atomic Energy Authority's research reactor " DIDO," where it is employed to recombine deuterium and oxygen emanating from the dissociation of the heavy water moderator.

Another application of catalytic recombination units is to power reactors of the boiling water type. Here the recombination is applied in a sealed system, to hydrogen and oxygen carried in a stream of high pressure



Recombination unit for deuterium and oxygen

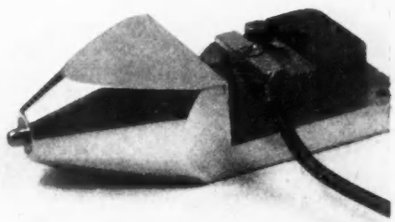
steam at elevated temperatures. The continued efficient operation of the catalyst under these conditions raises certain problems such as catalyst stability, corrosion resistance, &c., and these have been studied by the Research Division of Engelhard Industries. As a result of this work, an entirely new type of catalyst is now offered for recombination in steam at temperatures of around 500 deg. Cent. The very high efficiency of this catalyst permits almost complete reaction ; the residual uncombined oxygen after the recombiner is, we are advised, less than 0·1 part per million.

A further item of equipment for the non-destructive testing of materials was shown this year by Cawkell Research and Electronics, Ltd. Named an Impulse Materials Tester, it is used to measure the velocity of propagation of a mechanical disturbance over a distance of the order of feet ; a pulse is impressed by means of a hammer, and the interval between its arrival at two accurately located points is measured. It is considered that this technique is suited to the testing of roads and aerodrome runways ; our footnote* gives references to published work indicating a correlation between pulse velocity and flexural strength for concrete.

Several exhibits exploited the properties of indium antimonide, particularly that of varying its conductivity with alteration of the ambient magnetic field. It was demonstrated that this property could be used, in conjunction with a very sharply graded magnetic field, to detect movements in space such as are measured in Ångstrom units. We illustrate a displacement transducer exhibited by G. V. Planer, Ltd.; the arrangement comprises a magneto-sensitive indium antimonide resistor within a magnetic circuit. The varying degree of magnetic shunting of the indium antimonide element produced by the moving object under test manifests itself as a corresponding change in resistance, which is used to monitor the displacement. This micro-displacement sensor employs the Corbino disc element, a resistor configuration wherein the two electrodes are in the form of a peripheral conducting ring and a concentric conducting spot respectively, both applied over the magneto-sensitive resistance layer. The Corbino disc is the most favourable configuration in regard to sensitivity where the magneto-resistance effect in indium antimonide (as opposed to the Hall effect) is utilised, we are advised.

A powerful technique in the chemical laboratory is chromatography, and there was displayed by W. G. Pye and Co., Ltd., an argon chromatograph with which, it is claimed, sensitivities some 100,000 times greater than previously obtainable are possible : the effects of such variables as temperature, pressure and flow upon the argon detector are so insignificant that the degree of control is set solely by the column requirements. This makes possible a simplified apparatus with few controls and capable of being operated by non-specialists, we are advised.

The unique feature, proposed by Dr. J. E. Lovelock, is that argon is used as the carrier gas : this is excited into its metastable state on entering the detector. The excitation energy of argon is 11·6 electron volts and as this level is higher than the ionisation potential of organic vapours, any organic vapours present in the carrier gas are ionised on collision with excited atoms as they enter the detector : this causes a considerable increase in current through the cell. Furthermore, the electrons emitted when organic vapour molecules are ionised are able to enter into the process of producing more meta-



Probe of indium antimonide displacement transducer

stable or excited argon atoms. Such an effect depends upon cell voltage, so that with an increase in voltage greater sensitivities are obtainable. The sensitivity range is approximately one part component in 2×10^6 to 2×10^3 parts of carrier gas (argon) for full-scale deflection on the recorder. The limit of detection is one part component in 2×10^8 of carrier gas, or 10^{-11} moles.

Minute samples, in the order of 0·1 microlitre to 0·025 microlitre, are inserted quite simply by a micropipette. No overloading occurs since a smaller proportion of liquid phase is used : as a result, column efficiencies in the order of 1000 theoretical plates per foot length of column are obtainable.

* 1. Lang and Kurz, *Journal American Concrete Institute*, 1945, 16.
2. Mitchell, *Proc. Highway Research Board* (U.S.A.), 1954, 33.
3. L'Hermite Conference I.C.F., 1951 (France).
4. R.I.L.E.M. (Belgium), 1955.

OIL FIND IN LINCOLNSHIRE.—The British Petroleum Company, Ltd., announces that the B.P. Exploration Company has discovered oil at a depth of 4600ft near Gainsborough in Lincolnshire. Production is at the rate of 15 tons per day. The company also states that the total production of crude oil in 1958 from existing B.P. fields in the United Kingdom was about 80,000 tons.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

DIRTY HANDS

SIR,—If I may be permitted a final word on the above subject I would say that the human race to which many of your readers will belong has often been able to reach agreement on what is wrong, but seldom on what is right. That is why, when E. G. Semler (January 9, 1959) feels that we are in agreement over practical training, we agree only that it is wrong for engineers not to have practical training and we do not appear to agree what constitutes such training. Wrongly, perhaps, I felt that Mr. Semler's attitude was rather reminiscent of Captain Dalroy's on that other important subject " I don't care where the water goes if it doesn't get into the wine." My contention was that much of what passes for practical training was ineffective. What is instinctively felt to be of value in practical training could be realised in a very short time if we were quite clear what is of real value. There is a need for research into what is required of practical training and the best ways of achieving it. Experience on assembling jobs which are difficult or near impossible to fit, does not teach that such methods are to be avoided, rather does it encourage that familiar philosophy—" leave it to the chaps in the works, they'll find a way of getting around it."

The great difficulty is the nature of the engineering industry which is not unified and simple in character any more than engineers are, although some of us may be more simple than others. As Chesterton said somewhere, " Because every man is a biped, fifty men are not a centipede," and any attempt at laying down hard and fast rules will fail unless there is a clear conception of the point of practical training. My remark which Mr. Semler queries, " Given sufficient experience it is possible to predict that nothing at all will work," was a comment on the negative attitude of some " experienced " engineers to ideas or proposals which are new to them, and is meant to emphasise the point that not everyone's practical experience is an asset to them. My own belief is that an engineer obtains his really valuable experience as an assistant to a competent and really experienced senior engineer. A sympathetic and encouraging older man at this time of the young engineer's life can give him a priceless wealth of knowledge, experience and general know-how, and I believe the affection and regard for his chief, which the younger man acquires at this time, to be one of the most rewarding experiences of his life. It is in this way that I feel the individual older engineer can best help and not by sitting on committees, which may well turn him into a professional myope. Mr. Semler has not convinced me at all on car design and anyone that sets off in a snowstorm in a car, with a flat battery, dirty plugs and without looking at the dip stick, should not attempt to go beyond the railway station or the home for incurables, whichever is the nearer ! As for testing a prototype car, which is likely to break down in the pouring rain, your experienced engineer knows better than that and always sends his assistant !

One last point, I appear to have acquired a title since my original letter, and wish to quote the Walrus, who said, " Flattery will get you nowhere." However, I must admit the use of the appellation leads me to believe that Mr. Semler is a very nice fellow, indeed, and has at least one idea which would please me if realised.

CHARLES SIGSWORTH,
M.Eng., B.Sc., A.M.I.Mech.E.

Walsall,
January 19, 1959.

ROUGH-RIDING LOCOMOTIVES

SIR,—My experiences during recent years of French locomotives impressed me very much, and no secret was made of this in the resulting articles published in THE ENGINEER. Nothing struck me more than their good condition, which was reflected in their fine riding—both qualities were almost universal, and made travelling on them a very real pleasure. In my articles I referred to this time and again : some readers may have thought the panegyrics overdone, and foreseeing this, I assured them that there was no exaggeration—good condition and good riding were the rule, not the exception. It was justifiable to draw a comparison between French and British locomotives, and truth compelled me to say that it was difficult to do so without again being accused of overdrawing the picture : surely the average British locomotive's behaviour did not fall so short of its Gallic opposite number ? I am sorry—it does ! To prove it, one has only to ride a dozen or so British locomotives of different types, in their average condition—which will vary from good to very bad—then cross the Channel and do the same thing in France, ending the two experiences by returning to London from Dover or Folkestone on a " Britannia." That will convince you, if you have not quite made up your mind before ! This is not prejudice—it is truth—as a matter of fact, I like the " Britannias." They are fine engines, with many good points, but good riding is not one of them—they are hard, harsh, vibratory ; one notices it at once after coming off a Chapelon " Pacific." My admiration of French locomotives is based on experience and is justified ; I have no sympathy for

" The idiot who praises with enthusiastic tone,
All centuries but this, every locomotive but his own."

But honour should be given where honour is due.

It was suggested in the articles that British locomotive people should go over to France and experiment for themselves : they would soon come to the same conclusion that I did, and learn a good deal of value. I did not advise my French friends to do the same thing in Britain ; after all, *cui bono* ? One, however, did, and rode a " Britannia," but I was too diffident to ask him what he thought of its behaviour. Again, *cui bono*—the French are a polite people—he would never have told the truth ! But another S.N.C.F. man has now taken the plunge, and has actually said what he thought of the riding of the engine he sampled, though I have no doubt he toned down his real opinion—repeat : the French are a polite people. A friend has sent me a cutting from an English paper which is here appended :

" A French Express Driver's Holiday. Riding on the ' Bristolian.' Monsieur André Duteuil, a French express driver, travelled yesterday on the footplate of Britain's fastest train, the ' Bristolian,' and covered the 118 miles from London to Bristol in 105 minutes. At one point the ' King George V ' engine touched 100 m.p.h. On the Paris Lille run Monsieur Duteuil is allowed to drive at only about 70 m.p.h. (Incorrect—should be 81. E.H.L.) His only criticism of the ' Bristolian ' was : ' The springing does not seem so good as on my engine.' "

The driver, Joe Ward, said : " André did not drive, but tried his hand at firing. On holiday, Monsieur Duteuil wore his blue uniform and goggles for the ride." (*re* goggles : sensible man—one needs them on a " King.")

Monsieur Duteuil is apparently a Nord Region driver, running between Paris and Lille, where he handles the fine Chapelon 4–8–2s, and the de Casos 4–6–4s, four-cylinder compounds, and all superlatively good-riding engines. He, as an experienced locomotive man, would not expect equally good behaviour from an old 4–6–0 " King " —he would have been disappointed if he had. But it is interesting that he commented on the " springing " ; he, too, noticed the entirely different " feel " of an English locomotive. It must have been a complete contrast ; if he had ridden a " Britannia " his comments might have even cancelled his Gallic courtesy. My experience of a " King " only extended to one run with the " Riviera Ltd." twenty years ago, and the only reference I find to its riding in the article based on the trip (THE ENGINEER, April 14, 1939) was : " The riding of the engine was rougher than that of the northern ' Pacifics,' and at Edington, where the track, built on a clay formation, is very hard to keep in shape, it was superlatively harsh and bumpy. The engine was generally steady running, the original side-play allowed to the trailing axle having been done away with, as it had proved objectionable." So there was nothing much to complain of about that " King "—but I had never ridden a French locomotive then! The next time I am in France I shall make a point of contacting driver Duteuil, to find out what he really thought of things—after the friendly atmosphere of " La Maison Blanche " has loosened his tongue and politeness no longer inhibits him. I look forward to this—it will be interesting !

With one exception only, all the engines I

rode on the S.N.C.F.—at least 100—were good-riding. The solitary contrast was the forty-three-year-old "Pacific," pushing a dead electric locomotive ahead of it at 105 m.p.h., which could be described as rough, but under the circumstances this was only to be expected—in fact, it was creditable that it remained on the track! Some British engines have been good; a few very good; instance, the rebuilt Bulleid "Pacific" and that wonderful Gresley "V2" over which I rhapsodised in THE ENGINEER of October 13, 1939, with the whisky-flask and long-spouted oil-can standing on the cab floor as No. 4793 sped over the twisting track towards Aberdeen and these oscillation-meters remained vertical. British engines evidently can—or could—ride well, but they seldom do nowadays. This is not a minor matter; rough-riding bespeaks wear-and-tear to both engine and track, and that ultimately means money. I have ridden engines in both Canada and Britain that felt as though they were falling apart, and tearing the track to pieces; they probably were. I have never come across an engine like that in France.

EDWARD H. LIVESAY

Victoria, British Columbia,
January 13, 1959.

CONCEPT OF COMPLEMENTARY ENERGY

SIR,—In his review of the recent book *Problems in Engineering Structures*, by R. J. Ashby and A. H. Chilver, in your issue of January 16, your reviewer states that the concept of complementary energy was introduced by H. M. Westergaard in 1942. The concept of complementary energy is, however, dealt with in F. Engesser's celebrated paper "Ueber statisch unbestimmte Träger bei beliebigem Formänderungs-Gesetze und über den Satz von der kleinsten Ergänzungsarbeit," which was published in *Zeitschrift des Architekten-und Ingenieur-Vereins*, Hannover (Vol. 35, column 733), in 1889.

T. M. CHARLTON

Engineering Laboratory,
Cambridge,
January 19, 1959.

INITIAL PROTECTION OF STRUCTURAL STEEL

SIR,—In my capacity as chief engineer of a heavy chemical works, one of my routine jobs is the perusal of tenders. I am appalled at the low standard of initial protection offered by steelwork and equipment fabricators when tendering for structural steel and equipment not fully covered by specification. So often one reads "to be given one coat of red oxide paint before despatch," which, in practice, means over all the mill scale and shop rust. There seems to be no desire to deliver the equipment in a condition which would reflect credit on the supplier. Even if price competition makes impossible the more extensive metal treatments, shot-blasting, followed by a self-etch primer and suitable undercoat would soon produce repeat orders from satisfied customers.

The full answer is for the customer to specify the treatment he requires, and to be quite critical of the resultant finish. In many cases this may mean transferring the steelwork or equipment to a specialist metal finishing company and creating, as a result, some complications. This is, however, often the case when a standard industrial finish, such as hot-dip galvanising, is necessary, and there should not be any greater difficulties if, for example, metal spraying or one of the new spray finishes such as "Epikote" or Neoprene treatment is specified.

Adequate protection is not just a question of appearance. Corrosion costs this country millions of pounds a year, and no engineer worth his position can afford to accept anything less than the best in this respect.

R. A. DUCKWORTH

Romford,
January 14, 1959.

Book Reviews

Compact Heat Exchangers. By W. M. KAYS and A. L. LONDON. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 46s. 6d.

THE experimental work on heat transfer to various types of heat-exchanger surface which has been in progress for a number of years at Stanford University, under Professor London, will be familiar to most users of heat transfer data. Interim reports on this work have been published from time to time by the present authors and their collaborators, and this book now presents, in a form suitable for use in design, the whole of the results obtained. Also included are measurements made at the U.S. Naval Experimental Station as part of the same research programme, and also a small amount of information published by other investigators.

The heat transfer surfaces examined fall into four main categories: first, flow through and across banks of tubes, including circular-section tubes, flattened tubes and dimpled tubes; secondly, plate surfaces having various kinds of plate and pin fins; thirdly, flow normal to banks of finned tubes (the case of flow parallel to the axis of a finned tube is not dealt with), and, fourthly, the screen and sphere matrices used in regenerative heat exchangers. For all configurations the non-dimensional heat transfer and pressure-drop data are presented in tabular and graphical form, and this large amount of information forms the principal part of the book. It is noteworthy that the authors have not found it worth while attempting any general correlation of the results from different geometrical arrangements, with the single exception of flow normal to staggered banks of tubes. In this one case the results for various tube pitchings are condensed into a single diagram.

Apart from these experimental results, the book contains a number of shorter sections in which various factors entering into the calculation of heat-exchanger performance are considered. In Chapter II the relation between overall performance and the basic heat transfer rates is discussed for the various possible arrangements of recuperative heat exchangers—counter flow, parallel flow, &c.—and also for the liquid-coupled and regenerative forms. In this analysis mean-temperature-difference methods are avoided and instead relations are derived between "effectiveness" and the variable designated NTU. This approach is a perfectly logical one and appears to have some practical advantages over the more commonly used methods of calculation. In Chapter III methods are recommended of taking account of the effects on fluid properties of the variations of temperature along and normal to the flow direction, where these variations are large. Chapter IV presents data on losses at sudden expansions and contractions, and Chapter V contains some theoretical solutions for laminar flow through tubes.

In general, although the book is not intended to cover the whole range of problems met with in heat-exchanger design, it will form a valuable data book for use in design work.

Physics and Mathematics: Progress in Nuclear Energy, Series I, Volume 2. Edited by D. J. HUGHES, J. E. SANDERS and J. HOROWITZ. Pergamon Press, 4, Fitzroy Square, London, W.1. Price 90s.

THIS book reviews the international development in theoretical and experimental reactor physics since the First Geneva Conference in 1955, without reference to the body of papers given at the Second Geneva Conference in 1958. This is a logical step because the growth of knowledge stemming from the exchange of information at the first conference has been mushroom-like. Presumably a third volume will appear in Series I when the material from the Second Conference has been sifted.

The present volume is concisely organised. The first two chapters, together with the first three chapters in Volume I, constitute a survey of the relevant cross-section data on heavy nuclides over the entire energy range of interest for reactor calculations. Chapter 3 gives an up-to-date account of the status of experimental and theoretical methods for reactor spectra determination. Chapters 4 and 5 provide data and critical assessment on more recently devised experimental techniques of neutron source standardisation and the use of pulsed neutron sources. The last three chapters deal with the theoretical aspects of reactor physics which have expanded rapidly with the aid of high-speed computers. Chapter 6 discusses the probability theory of resonance escape. Chapter 7 is concerned with some computational methods for reactor calculations, and Chapter 8 reviews the Monte Carlo technique with reference to neutron transport theory. These last three chapters provide incidentally a very useful contribution to numerical analysis techniques which are making other complex fields, such as flame theory, more tractable.

Maintaining the standard of Volume I, this volume forms a review study of the highest quality in concept and achievement. If as a reference work it is not exhaustive, it is fundamental and derivative.

Books Received

Instruments Electroniques de Mesure. By E. H. W. Banner. Dunod, 92, Rue Bonaparte, Paris (6e). Price Fr.5.400

Anton Philips of Eindhoven. By P. J. Bouman. Weidenfeld and Nicolson, 7, Cork Street, London, W.1. Price 30s.

Rock Pressure in Mines. By E. de St. Q. Isaacson. Mining Publications, Ltd., Salisbury House, London, E.C.2. Price 45s.

Conference on Lubrication and Wear. Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1.

Statistics of Extremes. By E. J. Gumbel. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 120s.

Vacancies and Other Point Defects in Metals and Alloys. Institute of Metals, 17, Belgrave Square, London, S.W.1. Price 40s.

The Pump Users Handbook. By H. Addison. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 30s.

Properties of Materials at High Rates of Strain. Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1.

The Theory and Design of Magnetic Amplifiers. By E. H. Frost-Smith. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 75s.

On the Bi-Centenary of the Birth of Robert Burns

By A. K. BRUCE

IN the preface to the first edition of his poems printed at Kilmarnock in July, 1786, Robert Burns tells how they were written "To amuse himself with the little creations of his own fancy, amid the toil and fatigue of a laborious life ; to transcribe the various feelings—the loves, the griefs, the hopes, the fears—in his own breast ; to put some kind of counterpoise to the struggles of a world, always an alien scene, a task uncouth to the poetical mind—these were his motives for courting the Muses, and in these he found poetry to be its own reward." To-day, when the two-hundredth anniversary of his birth on January 25, 1759, is being commemorated all over the world, it is fitting to recall something of the conditions, social and industrial, which obtained in Great Britain two centuries ago, conditions which must have influenced the mind and heart of Burns, conscious as he was almost from the outset of a peculiarly keen sensibility. We know from a letter addressed by him to Mrs. Dunlop of Dunlop that Burns was "irritated and prejudiced on the gloomy side by a series of misfortunes and disappointments, at that period of my existence when the soul is laying in her cargo of ideas for the voyage of life."

Alike to the engineer and to the industrialist acquainted with the writings of Burns, significance attaches to the fact that the poet was born at a time when a day-labourer's wages in Ayrshire varied from 1s. 4d. to 1s. 6d., and when it was difficult for a woman to earn more than 1s. 8d. per week at the spinning of fine linen yarn.* We need to remember that Burns was born just before the advent of factory mechanisation and machine-powered production processes, an era which has been regarded as having commenced with the introduction of the spinning jenny.

The atmospheric steam engine had of course made its appearance nearly half-a-century before the poet first opened his eyes, so that steam power was affording some assistance to production in certain industries. When Burns came into the world James Watt had already spent twenty-three years in it and was about to set up in business with John Craig supplying mathematical instruments, musical instruments and "toys" at a shop in the Saltmarket of Glasgow. Six years were to elapse before Watt, walking "on a fine Sabbath afternoon" in Glasgow Green and meditating on the problem of keeping the cylinder hot and yet condensing the steam, arrived at the idea of operating the atmospheric steam engine with a separate condensing vessel from which the air and water would be extracted by a pump. Watt's patent was granted in 1769 and it is a singular coincidence that Arkwright's patent for the spinning frame should also have been sealed in 1769. The combined effect of the two patents was to prove incalculable, the utility and productivity of Arkwright's machine being multiplied out of all recognition by the application of steam power. Within a year from the date of the birth of Burns the first iron furnace at Carron had been blown-in and during 1760 the Carron Works turned out 1500 tons of manufactured iron, this being the entire tonnage produced in Scotland. Consideration of these particulars will show that by the time the poet had reached his tenth year, some of the major ingredients for the industrial era were coming prominently into view. On reaching his twenty-second year Burns made a temporary change in his occupation : working on his father's farm at Lochlea "his wages as a ploughman never exceeded six or seven pounds sterling per annum" and it occurred to him that as flax was cultivated on the farm there could be some commercial advantage in dressing as well as raising it. This necessitated the acquisition of some practical knowledge of the art of flax-dressing and as his mother had a half-brother engaged in the flax-dressing business, Burns moved to Irvine and set about acquiring the art. He did this in a small heckling shop where for ten hours or more each day he "bent over his bench drawing the rough flax through the heckles," the tools which he used being extant. The destruction of the heckling shop by fire put an end, in the early days of 1782, to the poet's flax-dressing experience which, incidentally, had seriously affected his health. It is mentioned here as having been a brief but important episode in his life and Burns has himself testified to the influences which, brought to bear on him in Irvine, encouraged him "to endeavour at the character of a poet."

The iron had been flowing from the Carron furnaces for twenty-seven years when Burns, then aged twenty-eight, happened to visit the district along with his friend Dr. Adair. Recording the impression made on the poet by the aspect of the works, Adair relates how Burns, wishing to inspect them, sought admission. The day was a Sunday (August 26, 1787) and entry was refused though it has been stated that the poet, when applying for permission to see the works, did so under a fictitious name. Thus rebuffed, he scratched the following lines on a window pane at the inn :

"We cam na here to view your warks,
In hopes to be mair wise,
But only, lest we gang to hell,
It may be nae surprise ;
But when we tirl'd at your door,
Your porter dought na hear us ;
Sae may, should we to hell's yetts come,
Your billy Satan sair us."

At the time of the visit the works at Carron had, as mentioned above, been in existence for less than thirty years, and as the pioneer industry of the kind in Scotland, reluctance to admit unidentified visitors can be understood. It may be noted, also, that in the years separating the birth of Burns from the time of his visit to Carron, the Watt steam engine had become widely known and was already being used quite extensively in its rotative form, the first of the engines at Albion Mill, Southwark, having been erected in 1786. It was this installation, which, in the opinion of James Watt, "formed the commencement of that system of mill-work which has proved so useful to this country." Incidentally, the engineer responsible for the "mill-work" at Albion Mill was the celebrated John Rennie, born two years later than Burns.

Rather more than a year after his encounter with the Carron Company, Burns was present at Dalswinton Loch on October 14, 1788, when trials were made on a boat built and engined at the expense of Patrick Miller, a banker much interested in ship design who was Burns' landlord at Ellisland, Dumfriesshire. The engine was designed by William Symington, propulsion being by paddle wheels. In a contemporary account of the trials it is mentioned that they "afforded great pleasure to the spectators," the vessel (it was 25ft long) being propelled at the rate of 5 miles an hour. Any impression made on Burns during this historic demonstration does not appear to have been recorded, but we can still see at the Science Museum, South Kensington, the engine which Burns saw at Dalswinton in 1788. Worth mentioning is the fact that during the year in which Symington's steam engine was demonstrated on Dalswinton Loch, Andrew Meikle, of Whitekirk, East Lothian, received grant of a patent covering the prototype of what came to be called the threshing machine, and was destined to prove of immense value to the agricultural industry, though it brought little pecuniary benefit to its inventor. Meikle, a highly skilled millwright, is remembered also for the part which he played in the training of John Rennie, who, while a student at the University of Edinburgh, spent his vacations in Meikle's workshop.

We may wonder whether, watching the operation of the steam engine on Dalswinton Loch, Burns recalled the laborious manual process of drawing the rough flax through the heckles which had exhausted and sickened him in the heckling shop at Irvine. Incidentally, the poet was not the only member of his family who had experience of employment other than that of agriculture. His brother William was a journeyman saddler and writing to Mrs. Dunlop on July 30, 1790, Burns mentions that he has just received a letter from London "acquainting me with the death of a brother of mine who was there a journeyman saddler. He was just twenty-three, a fine, worthy, young fellow." William Burns is known to have worked in London for a saddler named Barber, whose shop was at No. 181, Strand, just east from the top of Norfolk Street. He was employed here early in 1790 and news of his death reached Burns from John Murdoch, who, then settled in London, had formerly been school master to the poet and his brothers. In a letter addressed to Cromek, Murdoch mentions how "poor William, then in the bloom and vigour of youth, caught a putrid fever and in a few days, as real chief mourner, I followed his remains to the land of forgetfulness." It has been stated that William Burns was buried in St. Paul's Churchyard.

Turning from some of the technical and industrial events which transpired during the lifetime of Burns to those songs and poems which have rendered him immortal, it would be an impertinence to suppose that they need the formality of any introduction, nor is a technical journal the place to enlarge on them. Nevertheless, it is surely appropriate to acknowledge the ever-increasing debt due to the influence of the writings of Burns on those human relations which have become a vital factor in our national life and industry. Not so well remembered as it deserves to be is the impression made upon Adam Smith (1723–1790), author of *The Wealth of Nations*, by the first sight of the Edinburgh edition (1787), of Burns' poems. Adam Smith is generally admitted to have

* See *The Life and Work of Robert Burns in Irvine*, by the Reverend John C. Hill.

originated the study of political economy as a separate department of scientific inquiry, and *The Wealth of Nations*, first published in 1776, has been described as "the most important and influential work to which that century gave birth." We know from a letter addressed to Burns by Mrs. Dunlop on March 29, 1787, that Adam Smith had, on first seeing the Edinburgh edition of the poems, suggested that there might be procured for Burns the position of a Salt Officer, this being what he would have wished for himself had he been in narrow circumstances, since the duty was "easy, independent and free from that odium or oppression attached to the Excise." Mrs. Dunlop goes on to tell Burns that Adam Smith "has through life been a friend to unfriended merit, has great fame in the world as an author, both his *Theory of Moral Sentiments* and *Wealth of Nations* being much applauded. He was one of those first held forth your name forcibly to the public at Edinburgh when very few had seen your book and my son told me was the person he heard take the most interest in your future prospects, wishing to procure you leisure to write, which he said was all you wanted to insure your figure and fortune. He lately complained that he had asked it, but could not get a sight of you." It does not appear that Adam Smith ever did get a sight of Burns, but we read how the poet, on being asked by Mrs. Dunlop whether he had seen the philosopher, informed her (April 15, 1787) that "Dr. Smith was just gone to London the morning before I received your letter." He had, it appears, been rather seriously ill and his journey to London may likely have been for the purpose of seeing John Hunter.

We can hardly doubt that the author of *The Wealth of Nations*, emphasising as he did the importance of manufacturing industry at a time when the so-called agricultural system still predominated in economic teaching, recognised not only the essential part which would need to be played by human relations but the stimulus given, in the writings of Burns, to the promotion of human relations based on justice, honesty, sympathy and humanity. While it has not been usual to couple the names of Robert Burns and Adam Smith, readers of Smith's *Theory of the Moral Sentiments*—which, singularly enough, was published during the year in which Burns was born—will have no difficulty in recognising affinity between the two. The philosopher expounds among other things, such elements of human nature as sympathy, conscience, selfishness, virtue, propriety, anger and retaliation. Burns, who himself earned a precarious living as a small farmer, remarked (repeatedly, we are told) to his brother, Gilbert, how "he could not well conceive a more mortifying picture of human life than a man seeking work. In casting about in his mind how this sentiment might be brought forward, the elegy 'Man was made to Mourn' was composed." He also declared that "the joy of my heart is to study men, their manners and their ways, and for this darling subject I cheerfully sacrifice every other consideration." It was this study which, together with his experience, led Burns to become a fervent exponent of the innate dignity of the individual man and, while he is but one of many exalted enthusiasts for human brotherhood, he possessed the rare gift of conveying his message and expressing his feelings in language burning with the heat of its own compression. To-day, nearly two centuries after the time of Robert Burns and Adam Smith, good relations between management and workmen is seen to be increasingly dependent upon recognition of the dignity of the human individual.

Were Burns or Adam Smith with us to-day, they would be amazed and shocked by the divisions set up among nations and groups of nations; divisions maintained by such barbarous anachronisms as "iron curtains" and "cold wars." They would also deplore all industrial and political strife destructive of national and international welfare. In this connection Burns has left some lines which we in Great Britain will do well to remember:

> "O let us not, like snarling tykes,
> In wrangling be divided,
> Till, slap! come in an unco loun,
> And wi' a rung decide it!
> Be Britain still to Britain true,
> Among oursels united;
> For only but by British hands
> Maun British wrangs be righted."

The above text is as given in a letter addressed by the poet to Mrs. Dunlop during the midsummer of 1795, about a year before his death. The splendid ballad from which the lines are taken was first published on May 4, 1795, in *The Edinburgh Courant*. Issued as a sheet-song and widely circulated, it "did more" (says Cunningham) "to right the minds of the rustic part of the population than all the speeches of Pitt and Dundas, or the chosen Five-and-Forty." Six months earlier, Burns had sent to Thomson five verses with the title: *A Man's A Man For A' That*; lines which may be said to have become more familiar and more frequently quoted throughout the world than any other of his poems. They were certainly among those in which (as was remarked by John Buchan) "Burns gave Scotland her own French Revolution, burned up much folly with the fires of poetry, and reconciled in common humanity warring elements in the national life." Burns, in his letter to Thomson, describes *A Man's A Man For A' That* as "not really poetry." How deep would have been his astonishment could he have known that two hundred years after his birth the eight lines with which it concludes were to be reverberating not only in Britain but throughout the world:

> "Then let us pray that come it may,
> (As come it will for a' that),
> That Sense and Worth, o'er a' the earth,
> Shall bear the gree, an' a' that.
> For a' that, an' a' that,
> It's comin' yet for a' that,
> That Man to Man, the world o'er,
> Shall brothers be for a' that."

That this bugle-note of democracy will continue to reverberate we cannot doubt.

Crewe Works—The Last Steam Locomotive

By E. C. POULTNEY, O.B.E.

ON Monday, December 15 of last year, the last steam locomotive to be turned out of the Crewe works was completed, thus bringing to an end over 100 years of steam locomotive construction at a famous works, responsible for the construction of no fewer than 7331 locomotives, many of which have typified in one respect or another defined steps in the development of British locomotive practice. No attempt will now be made to chronicle even in the barest outline the work done at Crewe since the works were opened in 1843. This would be impossible, but it is, nevertheless, interesting to call attention to the fact that the large 2–10–0 engine No. 92250, the last to be built at Crewe, is for freight traffic. For almost from the first Crewe works has been noted for its goods locomotives. The celebrated "Crewe Goods" locomotives, the first for this particular traffic and almost the first locomotives to be built at Crewe, appeared in 1844, or one year after the works were opened.

These famous engines were, it may be remembered, built by Alexander Allan, Francis Trevithick being the locomotive superintendent, for service on the Grand Junction Railway, and subsequently worked goods trains for many years on the L. and N.W.R. after its formation in 1846. Through the courtesy of British Railways, London Midland Region, I am enabled to illustrate Allan's design of 1844 (Fig. 1) and for comparison the engine No. 92250 (Fig. 2) one of the B.R. standard engines Class "9" built for heavy freight traffic from the designs of Mr. R. A. Riddles, member for mechanical and electrical engineering of the former Railway Executive. The difference seen in these examples of Crewe-built locomotives is, to say the least of it, striking. On the one hand, Allan's engine turned the scales at 19·25 tons, engine only, while the 2-10-0

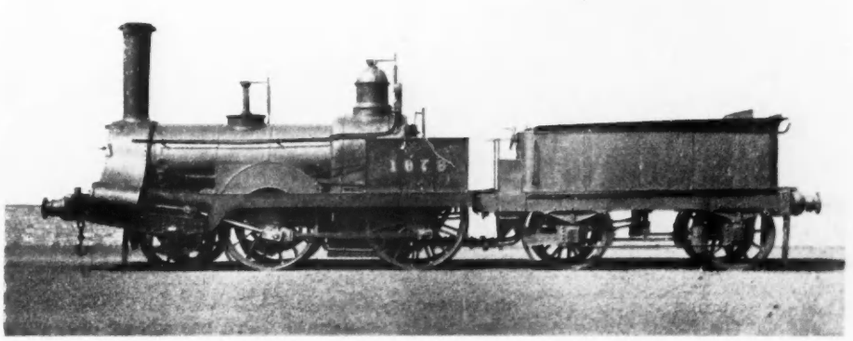


Fig. 1—The first goods locomotive to be built at Crewe, Allan's 2-4-0 "Crewe Goods" engine, built at Crewe works, 1844

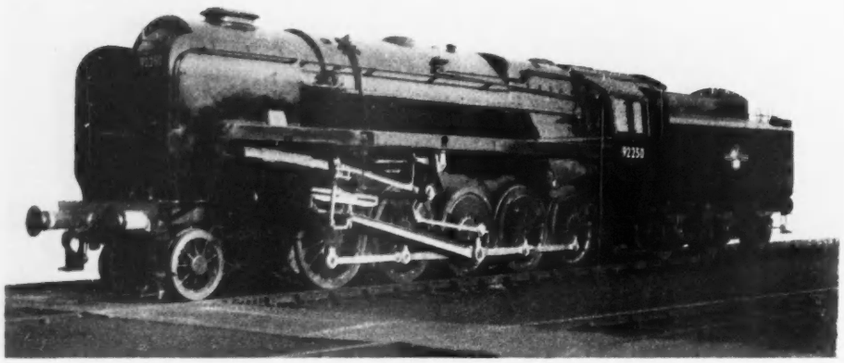


Fig. 2—The last steam locomotive built at Crewe works

engines weigh, engine only, 86·7 tons, and have a rated tractive force of 39,667 lb, comparing with 7668 lb for the 2–4–0 engines of 1844.

Though historical accounts of British locomotive developments naturally mention Allan's "Crewe Goods," information concerning their dimensions has been sadly lacking; aided, however, by his friend Charles Simpson, the writer is enabled to present below some particulars of these historic locomotives, which will, at any rate, fill the gap in one's knowledge to some extent and will, therefore, no doubt be of interest.

Allan's "Crewe Goods" Engines—1844–1857

Cylinders, diameter and stroke, inches	15 by 20
Wheels coupled, diameter, inches	60
Steam pressure, lb per square inch	120
Heating surfaces, square feet :	
Tubes	696·62
Firebox	54·14
Total	750·76
Grate area, square feet	9·9
Weights, tons :	
On leading wheels	5·75
On leading drivers	9·0
On trailing drivers	4·5
Engine—Total	19·25
Maximum tractive force, lb	7668

The first one of these engines had 13in cylinders; the others had 15in, and for those built later the cylinder diameter was increased to 15¼in. In all cases the 20in stroke was maintained.

Some particulars of the boilers from which the heating surfaces have been estimated, are as follow :—Firebox, dimensions, inside, length 3ft, width 3ft 2in, height 3ft 10in. The boiler tubes, 158 in number, had an outside diameter of 1¾in and were 9ft 7½in long. The writer is not sure of the weight of the four-wheeled tender, but thinks it was about 12 tons when loaded.

While the photograph, in general, seems to show these engines as originally built, it differs in this respect by showing a Webb chimney, and the buffers are also of a more modern type. As already mentioned, these engines were in service for many years on the L.N.W.R., certainly up to the closing years of the last century. Many of them were rebuilt as side tank engines for light duties in their declining years.

The B.R. standard engines like 92250 have already been fully described in the pages of THE ENGINEER; suffice it, therefore, to say that the two cylinders are 20in diameter, with a piston stroke of 28in, and that the boilers, carrying a working steam pressure of 250 lb per square inch, have a total of 2550 square feet of heating surface and a grate area of 40·2 square feet. The coupled wheels, like the Allan engines, have a diameter of 5ft. The engine and tender, when ready for the road, have a total weight of 139·2 tons. A truly remarkable contrast with the engines of 1844.

Thus is recorded a story, the "Alpha and Omega" of Crewe-built designs, signalling the end of an epoch and the closing chapter of a steam locomotive history.

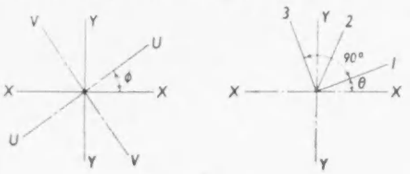
Solution of Strain Gauge Rosettes

By WILLIAM L. BRIDE, M.Sc.(Tech.), M.I.Mech.E.*

THE following notes explain a graphical method of analysing strain gauge rosettes with the restriction that two of the strain readings shall be measured in directions at right angles to one another. The third strain reading is preferably in a direction at 45 deg. to the others, but this is not essential.

Choosing a suitable stress scale, Fig. 3 is constructed by drawing a circle of radius $(\sigma_x - \sigma_y)$ about the origin of a pair of rectangular co-ordinate axes OP and OQ. $OP = OQ = (\sigma_x + \sigma_y)$, so that PQ is at 45 deg. to each axis.

$x\bar{X}$ and $y\bar{Y}$ are drawn normal to PQ. Then the co-ordinates of $\bar{X}$ and $\bar{Y}$ represent σ_x and σ_y. The radius OU is drawn making an angle 2ϕ deg. with the axis OQ. uw is normal to OQ and wU normal to PQ. Then the co-ordinates of U represent σ_u and σ_v (Fig. 1). Similarly, if this construction is performed for the radius making an angle $2(\phi + 90)$ deg. with the OQ axis, a point V is determined which has similar properties. Fig. 3 is drawn for the case where $\sigma_x > \sigma_y$, both positive. Fig. 4 shows the construction for the case where $\sigma_x > \sigma_y$ numerically, but σ_x is positive and σ_y is negative. This geometrical representation of stress is the basis of the method of rosette analysis.



Figs. 1 and 2

Knowing the values of E and ν for the material, a stress grid and strain grid are prepared, the one superimposed upon the other as shown in Fig. 5. These two grids are used for the solution of any number of rosette readings from the material for which they have been prepared.

The horizontal and vertical lines are lines of constant stress drawn at suitable intervals.

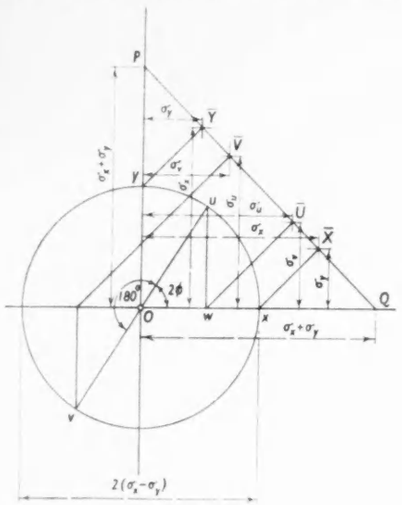


Fig. 3

The co-ordinates of any point with respect to the zero stress ordinates represent the normal stresses on mutually perpendicular axes in a material. The inclined lines are lines of constant strain, the zero strain ordinates for which pass through the origin of the stress ordinates and are inclined at an angle, $\tan^{-1} \nu$, to the stress ordinates.

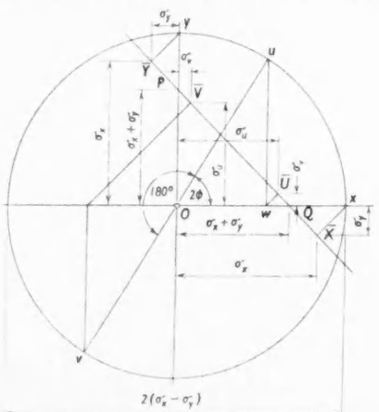


Fig. 4

For any point on the grid, strain values are measured as horizontal and vertical co-ordinates of the zero strain ordinates, the two strains being those on mutually perpendicular axes in a material.

Fig. 6 indicates the method of construction of the strain grid from the calculation of

Notation :

σ—Stress in a biaxial stress system.
e—Strain in a biaxial stress system.
E—Young's modulus.
ν—Poisson's ratio.

Suffixes x, y—Principal stresses or strains in X and Y directions respectively.

Suffixes u, v—Stresses or strains in arbitrary directions U and V respectively, at right angles to one another and making an angle ϕ with the principal axes, as shown in Fig. 1.

Suffixes 1, 2, 3—Directions of the three gauges forming the rosette numbered counter-clockwise as shown in Fig. 2.

θ—The angle between the X principal axis and No. 1 gauge measured positive counter-clockwise from the X principal axis as shown in Fig. 2.

Tensile stresses and strains are regarded as positive.

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strains for various stress values in simple tension.

The use of the grids for the solution of a rosette is shown by a worked example in Fig. 7. For clarity, only the essential constant strain lines are shown.

The measured strains and their directions are :

$e_1 + 0{\cdot}00035$ in direction of datum
$e_2 + 0{\cdot}00075$ at 45 deg. to datum axis
e_3 0·00015 at 90 deg. to datum axis.

A point (1, 3) is located on the strain grid corresponding to the strains e_1 and e_3, the former being taken as the horizontal co-ordinate and the latter as the vertical co-ordinate. Through this point a line is drawn at 45 deg. to the stress axes. This corresponds to the line PQ on Fig. 3 or 4. A point (2) is located on this line, the horizontal co-ordinate of which is the strain e_2.

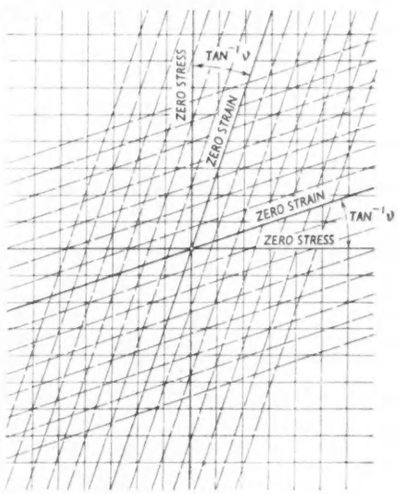


Fig. 5

From each of these points (1, 3 and 2) lines are drawn normal to the PQ line and, where these intersect the horizontal stress axis, vertical lines are drawn of indefinite length and numbered 1 and 2 corresponding to the points 1, 3 and 2 respectively.

The next step in the procedure requires a simple transparent template consisting of a

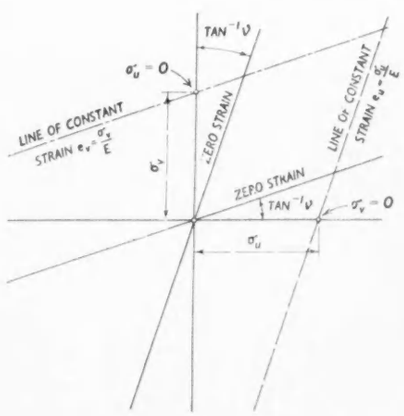


Fig. 6

number of concentric circles with two radii separated by an angle equal to twice that between gauges Nos. 1 and 2 which in this example is 45 deg., so that the radii are placed at 90 deg. to one another on the template as shown in Fig. 8. The radii are numbered 1 and 2 in the correct order corresponding to the gauge numbers. The template is placed over the grids, its centre coinciding with the origin, and rotated until the two radii are of equal length where they cut the two vertical lines already constructed on the grids, No. 1 radius cutting No. 1

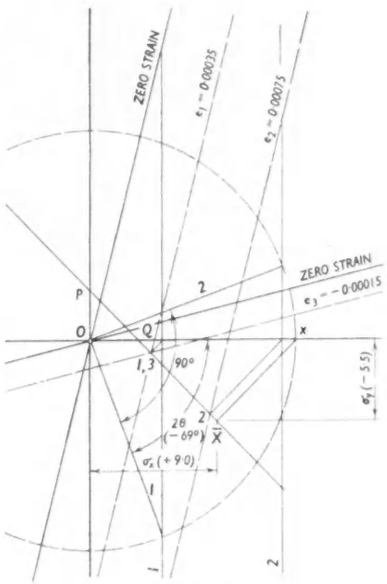


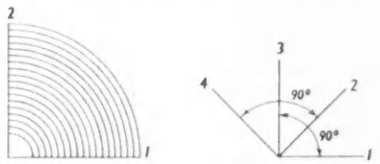
Fig. 7

vertical line and No. 2 radius cutting No. 2 vertical line. This radius is that of the $(\sigma_x - \sigma_y)$ circle in Fig. 3 or 4 and the positions of the radii correspond to twice the gauge direction angles. The angle between No. 1 radius and the OQ axis is 2θ (Fig. 2), due account being taken of sign. The line $x\bar{X}$ is drawn normal to PQ and $\bar{X}$ locates the principal stress point on the stress grid. The construction is completed and the principal stresses and their directions are taken from the diagram, giving :

σ_x = 9·0 tons per square inch
σ_y = 5·5 tons per square inch
2θ = 69 deg.
θ = 34½ deg.

The negative value for θ indicates that the X principal axis lies between gauges Nos. 1 and 2, i.e. θ is measured clockwise from the X principal axis to the direction of No. 1 gauge.

It is suggested that it might be useful to take four gauge measurements in the direc-



Figs. 8 and 9

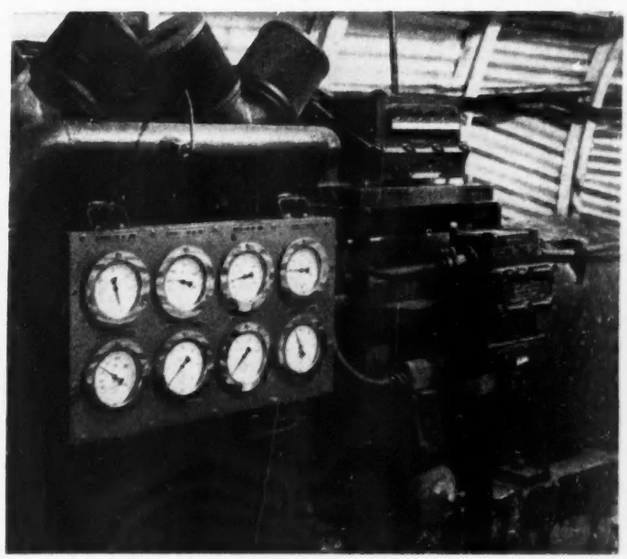
tions shown in Fig. 9. This will give two points on the grids (1, 3 and 2, 4) both of which should fall on the same PQ line, thus providing a check on the strain measurements. The remainder of the construction is as explained above.

Once the grids are prepared for the material in which the stresses are to be measured, a large number of rosettes may be analysed quickly. If the number of rosettes is few it is unnecessary to draw the grids. The construction may be done quite quickly on graph paper.

Automatic Supervisory Equipment

A COMPREHENSIVE protection system for air compressors, developed by Teddington Industrial Equipment, Ltd., with the assistance of the National Coal Board and leading compressor manufacturers, has been installed in a number of collieries in the Midlands and Durham Divisions of the N.C.B. The equipment, which can be used for installations both above and below ground, consists of a panel mounted on the compressor and, for underground use, a flameproof indicating unit, rotary switch and alarm bell. All the usual temperature and pressure gauges are contained in the panel in addition to the protective switches. By arranging for two instruments, such as two temperature switches, or a switch and a gauge, to be operated from the same sensing system or pressure union, the number of insertion points required on the compressor is reduced.

For underground use the panel operates on a 15V intrinsically safe supply, derived normally from a Davis "F.I.U." flameproof indicator unit. This houses six indicator circuits housing intrinsically safe a.c./d.c. relays and lamp indicators, together with two step-down transformers for the low-voltage protection and indicating circuit. A Davis flameproof rotary switch is operated to start the compressor motor. This unit incorporates two time-delay switches, one of which allows a twenty-second delay for oil pressure to build up before the shut-down circuit comes into operation, and the other gives protection against power failure. These flameproof components and the alarm bell are seen in the accompanying illustration.

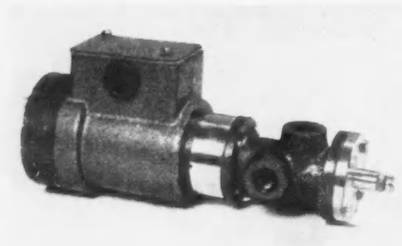


Compressor instrument panel, flameproof indicator unit, rotary switch (operating handle on underside) and alarm bell, fitted to a reciprocating compressor at Parkhouse colliery

If l.p. or h.p. discharge temperatures rise abnormally, the appropriate warning switch will break circuit and the relay with which it is associated will trip out. The relay contacts will close, one pair energising the alarm bell and the other energising the associated warning lamp. This provides advance warning of overheating and, if corrective action is taken before conditions deteriorate, the relays will reset automatically and the alarm will cease. If, however, either temperature rises to danger level, the shut-down switches will also break circuit and the shut-down relays will trip out. On changing over, one pair of relay contacts energises the appropriate fault indicator and the other breaks the motor starter holding circuit to shut down the compressor. No advance warning is given normally in the case of loss of lubricating oil pressure or loss of coolant. In either event the associated shut-down switches will operate and the compressor will stop immediately.

All the shut-down contacts of the relays are wired in series to ensure that when any one relay operates the motor pilot circuit will be tripped. The compressor can be stopped manually simply by turning the rotary switch to the off position. The system fails safe in the event of any fault or damage to its own components, so ensuring that the compressor cannot run unprotected, and also shuts down the compressor automatically in the event of mains failure or earth fault. For surface installations the separate indicator unit is replaced by a series of latched fault indicators in the panel itself.

A further addition to equipment made by the same firm for automatic supervisory purposes is a new solenoid-operated valve for overspill burners using oil of high viscosity. Being designed for use with fuel oil at viscosities ranging from 200 to 1000 seconds Redwood No. 1 at pressures between 0 lb and 300 lb per square inch, the valve has a double-wound solenoid to provide sufficient pull for overcoming stiction when plant is started up from cold. A changeover switch operated by the valve spool enables the operation of the valve to be interlocked with the burner programme circuit to ensure that the correct sequence is initiated and maintained. The switch can also be used to operate a remote valve position indicator.



Solenoid-operated valve for use with overspill burners, showing two of the three ports which allow normally-open or normally-closed operation

When the valve is energised, the armature—to which the spool of the balanced slide valve is attached—is attracted into the solenoid core against a return spring and in this position opens one of the outlet ports and closes the other. At the same time, it operates a multi-leaf switch, opening one set of contacts to disconnect the solenoid "pull-in" winding (the second or holding winding remaining energised), and changing over the second set from one signal circuit to another. The two sets of contacts are linked mechanically but are electrically independent.

Alternative outlet ports are provided so that the standard valve may be used either as a simple cut-off valve or as a diverter. One of the three ports is normally plugged, and by changing the position of the plug, the valve can be converted from normally-open to normally-closed operation. A built-in adjustable by-pass enables pre-heated oil to be circulated through the valve.

The solenoid is wound for 220V d.c. A small chassis-mounting rectifier can be supplied for use with a.c. supplies.

Burnhope Television Station, Co. Durham

AN alternative television service to a population of nearly 2,750,000 in the North-East of England has been made available by the opening on January 15 of the Independent Television Authority's transmitting station at Burnhope, Co. Durham. The station is 800ft above sea level and is equipped with two pairs of transmitters, each pair comprising one 4kW vision and one 1kW sound transmitter. All the main transmitting equipment for Burnhope has been supplied and installed by Marconi's Wireless Telegraph Company, Ltd., and is identical with that at the Chillerton Down (Isle of Wight) station of I.T.A. (described in THE ENGINEER of August 29, 1958). In the vision transmitters (type BD366) a considerable reduction in the number of valves used has made possible a clean and straightforward layout and the incorporation of a simple cooling system needing no sub-floor ducting. The design represents an approach to the production of a "packaged" equipment for a high-power television station. As at Chillerton Down, the two pairs of transmitters are used on a main and standby basis.

Control desk for the Burnhope vision and sound transmitters

The aerial system, also supplied and installed by Marconi's Wireless Telegraph Company, Ltd., is horizontally polarised and consists of two eight-stack quadrant aerials, one above the other, which will normally be used as a single sixteen-stack directional array. The aerial gain is of the order of 16 dB in the north-east and south-east directions, 14 dB to the east and 9 dB to the west. Thus, with a vision transmitter output of 4kW, the effective radiated power (E.R.P.) is approximately 100kW to the north-east and south-east, 70kW to the east and 20kW to the west. Each stack of eight is fed by its own main feeder and each could, if desired, be used as a separate aerial system radiating the combined output of one vision and one sound transmitter.

The aerial system is mounted at the top of a 750ft triangular mast. A new type of prefabricated coaxial feeder has been used in which there are no expansion joints, the cable being flexibly supported on runners and springs so that expansion or contraction can take place without any significant stress along the length of the run.

A variety of vision links has been provided for the new station by the Post Office. The station is connected by a single-way link with the Newcastle studios of Tyne-Tees Television, Ltd., and is also able to receive programmes from the main I.T.A. network via Telephone House, Manchester. A new Post Office network switching centre has been set up at Telephone House, Newcastle, to handle both network and local programmes.

Connections between Telephone House, Newcastle, and the local studios consist of four vision links (two in each direction of working) on coaxial cable. Each is 0·7 mile long and operates in the unbalanced video mode. All active transmission equipment is located at the Post Office terminal station.

The route from Telephone House to Burnhope is via Pontop Pike, the terminal of the microwave radio section of the link from Manchester. To Pontop Pike it consists of a new six-tube coaxial cable equipped to operate in the 3 to 7 Mc/s band. This line section is about 13 miles in length and in order to provide the necessary amplification at two intermediate points, the cable has been intercepted at Swalwell and Burnopfield. An additional channel, outgoing from Newcastle, will be provided later, when the Carlisle–Pontop Pike radio section of the Manchester–Pontop Pike link has been converted for both-way service, enabling programmes originating in Newcastle to be transmitted to the main I.T.A. network. From Pontop Pike to Burnhope a 5-mile unbalanced video link on a new coaxial cable has been provided.

Between Manchester and Carlisle a link, single-way at present, is provided on coaxial cable with carrier line equipment operating in the 0·5 to 4·0 Mc/s band. The Post Office terminals of this section are at Telephone House, Manchester, and Carlisle (Harraby) repeater station. Eastwards from Carlisle (Harraby) the various signals are carried by a microwave radio link operating at about 4000 Mc/s. This link, operated at present in one direction only, with portable equipment, consists of two sections. That from Harraby to an intermediate repeater station at Hopealone Farm, near Haltwhistle, is about 23 miles long, and the second section, from Hopealone Farm to Pontop Pike, is about 28 miles long.

The radio stations are unattended, indications of faults being extended by automatic alarms to other centres where Post Office maintenance engineers are always available. In addition, a duplicate set of equipment is automatically brought into service on failure of the operational channel. Later this year permanent equipment will be installed to provide a total of four channels, two in each direction of transmission, for operational and standby purposes.

The aerials, which will form part of the permanent installation, consist of parabolic reflectors, 10ft in diameter, with suitable waveguide horns and feeders, and are elevated on masts and towers to obtain unobstructed paths for the microwave radio signals. The above-ground height of the aerial at Carlisle (Harraby) is 150ft, and at Pontop Pike 40ft. Siting of the mast near Haltwhistle had presented some difficulty, because the high ground which would offer technical advantage is situated within an area which is reserved for a National Park. For this reason, the mast has been erected at a lower level, at the Hopealone Farm site, and a mast height of 260ft is necessary. The gain of each aerial is 39 dB.

The portable microwave equipment in service at present is similar to that used for outside broadcast purposes. The power output from each transmitter is approximately 300 milliwatts. Frequency modulation is employed, and the deviation is 4 Mc/s peak-to-peak for a 1V peak-to-peak video input. The equipment at the Hopealone Farm intermediate station consists of two terminal transmitters and two terminal receivers joined back-to-back at video frequency to form two demodulating type repeaters.

All the temporary radio equipment has been supplied by Standard Telephones and Cables, Ltd., which is also the contractor for the permanent equipment.

The permanent equipment will also operate in the 4000 Mc/s band, and will provide a total of four channels, two in each direction of transmission, for operational and standby purposes. The terminal transmitter will then consist of a reflex klystron which is frequency modulated by a pre-emphasised video signal (8 Mc/s peak-to-peak corresponding to 1V peak-to-peak), and a 4000 Mc/s travelling-wave amplifier. This serves as a buffer between the klystron and the aerial, and raises the power output to 5W.

Each permanent receiver at the intermediate station will be a 4000 Mc/s superheterodyne, with an intermediate frequency of 70 Mc/s, at which frequency most of the gain of the repeater (about 70 dB) is provided. Each receiver will be followed by a 70/4000 Mc/s frequency changer, and by a travelling-wave amplifier serving to raise the power output to 5W for re-radiation. The output frequency of the repeater differs from the input frequency by 213 Mc/s.

At the terminal station a similar receiver will be used, with the exception that the 70 Mc/s intermediate frequency will here by applied to a frequency discriminator for the purpose of recovering the original modulation. The signal, at video frequency, will then be amplified and de-emphasised to restore it to 1V peak-to-peak, at which level it will be applied to the coaxial cable for transmission to Newcastle, and thence to Burnhope.

The permanent installation will be the first Post Office broadband link to incorporate the technique of pre-emphasis at the transmitter and corresponding de-emphasis at the receiver. This technique offers advantages when applied to any broadband radio system which is designed to carry both television and multi-channel telephony. It also serves to simplify the method of automatic frequency control at the terminal transmitter.

Radiography for Miners

TO cater for the regular X-ray examination of mineworkers the National Coal Board is taking into service a fleet of nine mobile X-ray units which have been specially built to the design of the N.C.B. Medical Service. This scheme forms part of the Board's long-term campaign to control pneumoconiosis, which is caused by the dust produced when coal is mined.

The plan is to provide facilities for all workers in British coal mines to have voluntary radiographic examinations at regular intervals. Using the nine mobile units it is proposed to examine one-fifth of all the miners in the country every year, and then to repeat the process, giving every miner the opportunity of examination every five years. However, the interval between subsequent examinations will be open to adjustment to achieve the optimum results.

In conjunction with the Board's measures for dust suppression in mines, the X-ray scheme will provide a powerful means of controlling pneumoconiosis and reducing its incidence. The intervals between examinations will be such as to give the best chance of diagnosing the disease in its early stages. Apart from the importance of the scheme to each miner as an individual, it offers the prospect of providing the Board with important statistical data about the effectiveness of its measures to suppress dust in any given mine.

It is to be expected that during the first five-year period there will be a sharp rise in the certification rate of pneumoconiosis (it will not of course, imply a corresponding rise in the incidence rate of the disease). After the fifth year there would be a fall in the certification rate and the industry as a whole would benefit increasingly from the results of each subsequent series of X-ray examinations.

Each of the nine mobile radiographic units is self-contained for carrying out diagnostic X-ray examination. These units, each consisting of light alloy expanding bodywork, were designed and built by Bonallack and Sons, Ltd., to the requirements of the N.C.B. Medical Service, to carry a new design of X-ray equipment developed and made by Philips Electrical, Ltd. The prime mover is a Commer 7-ton forward-control vehicle, the engine being mounted below the floor line of the three-seater cab.

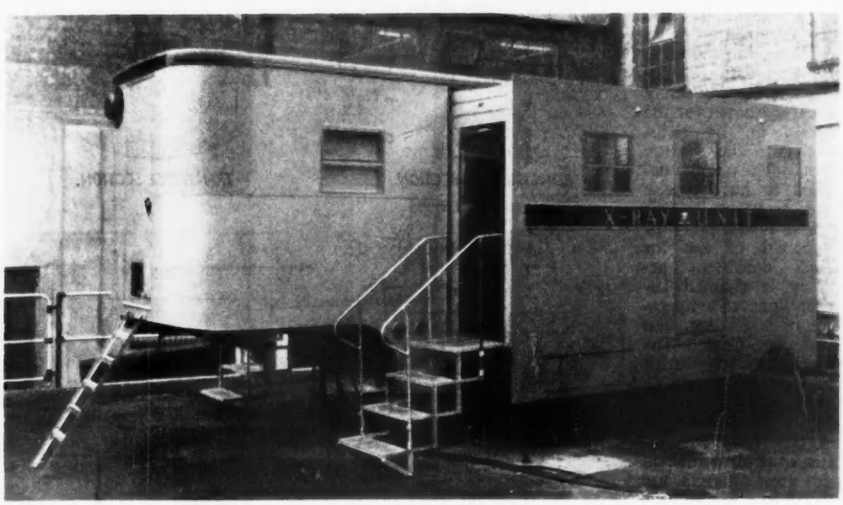
The body of each unit, mounted on a Carrimore semi-trailer chassis, is 25ft long and 7ft 6in wide when closed up for road travel; but on site

X-ray cubicle with sliding door and shield open showing the "Rotopulse" control panel and chest stand

both sides of the vehicle can be extended (as illustrated) to a maximum overall width of 14ft to provide closed and heated accommodation for all equipment, the staff of three and the miners to be X-rayed. These side extensions are effected by the use of box bearers, supported throughout by ball-bearing trunnions, the side walls being extended and retracted by means of double-acting hydraulic rams. Davis Magnet adjustable landing gear is fitted to the chassis and a series of captive bottle jacks ensures the stability of the unit when uncoupled from its towing vehicle, as illustrated here. It is stated that the crew can site and open up the unit in under half an hour and prepare it for full radiographic service within the next half-hour.

The X-ray equipment is known as the "Rotopulse"; it was developed originally as a general hospital unit for all techniques, including extremely short exposure times for heart radiography, but its characteristics are well suited to the kind of duty required by the National Coal Board. The "Rotopulse" embodies a motor alternator set specifically designed to supply impulse loads, the output of the alternator for any particular load being known with a close consistency. The alternator has an output frequency of 500 c/s, which considerably simplifies switching problems on exposure times to the order of 10 milliseconds.

The mobile unit is so arranged that power not only for the X-ray equipment, but for the heating and lighting also, can be taken through a transformer from the main electricity supply at the majority of collieries. Under these conditions the "Rotopulse" gives a consistent X-ray output, irrespective of voltage fluctuations in the supply. However, should the colliery mains supply be unsuitable (for example, outside the voltage range



Mobile X-ray unit sited ready for service, with sides extended to give a maximum width of 14ft. The X-ray examination cubicle is in the centre, and the surrounding space is used for circulation of personnel, documentation and changing

covered by the transformer) power can be derived for all purposes from the tractor engine through a Martin Harper power take-off; for radiographic purposes the total continuous load on the engine is only 5kVA, but the design permits an X-ray tube loading of 23kW. It was an essential requirement that radiographs of mineworkers should be of uniform density and that films taken at intervals of several years should be directly comparable. Accordingly, a new type of "phototimer" controller has been supplied; this device monitors on both lungs and in practice produces films with a very high degree of consistency. Automatic numerator devices have been embodied in the equipment to ensure that both radiograph and record card are marked with the same serial number at the time the exposure is made.

Our second illustration shows the examination cubicle and control cabinet. The installation includes a new design of chest stand developed for the National Coal Board, and the plinth upon which the patient stands is adjustable vertically to bring the subject into the correct position for radiography. A lead-lined steel enclosure shields the other patients in the van from radiation. Part of this protection consists of a U-shaped sliding shield which gives access to the X-ray cubicle as can be seen in the illustration. The shield is interlocked with the X-ray equipment, and when the shield is closed the patient can be seen through the observation window.

As can be seen from the first illustration the front end of the trailer is of fixed width; it houses a well-equipped dark room in which cassettes can be loaded and unloaded and X-ray plates processed.

The X-ray cubicle is roughly in the centre of the unit. When the unit is in service the miners enter by the steps leading to the door on the offside and circulate in the corridor space around the X-ray cubicle to the documentation clerk at the back and the changing space on the near side, where they strip to the waist ready for the examination. The exit door is on the near side as illustrated.

Self-Aligning Surveyors' Levels

TWO British firms have collaborated in the development of an optical device which automatically levels the line of sight in a surveyor's level. Both of these firms, namely, Cooke, Troughton and Simms, Ltd., and Hilger and Watts, Ltd., now have on the market an automatic level, which incorporates the optical device, but otherwise follows the respective firm's normal design practice. When using one of these instruments, it is set up approximately level, by observation of the bubble in a small circular spirit level (the sensitivity of which is 8 min per millimetre displacement). The three footscrews can be adjusted to bring the bubble within its circle, but having achieved evenly approximate horizontality in this way, no further adjustment is necessary, and accurate work can be done. Thus, these instruments are easy to use and give accurate results. It is claimed that field experience shows that double the speed of observation is achieved, with less risk of accidental error. The clean lines of the two automatic levels can be seen from the illustration; one of them is shown fitted with a horizontal circle which is observed through a second eyepiece.

The "optical stabiliser," as the levelling device has been termed, is illustrated in the sketch, which shows the device at full scale. The principle of operation will be apparent from the diagrams in the lower right-hand part of the sketch. The "stabiliser" is positioned between the focusing lens (an internally focusing telescope is used) and the cross hairs, but as the sketch shows, an additional lens is needed in the telescope so that it can be accommodated. It is positioned at a distance of one-quarter of the focal length of the telescope from the cross hairs and it consists, optically, of three prisms, of which the top one is fixed to the top of the telescope tube. The device is, in effect, a pendulum, the moving part of which comprises the two lower prisms. Thus, the diagram shows the path of a beam of light, and also the positions of the swinging prisms, with the telescope tube horizontal and slightly inclined respectively.

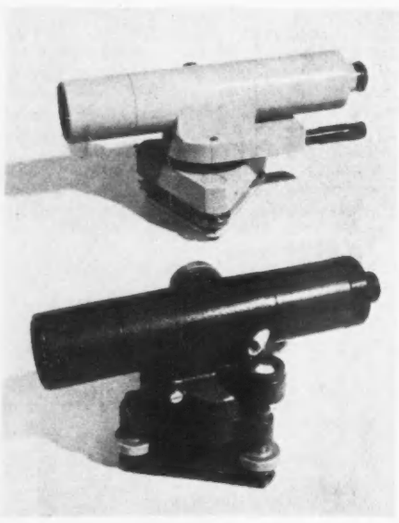
Further details of the construction of the stabiliser are shown in the sketch. The suspension of the pendulum consists of two crossed pairs of flexible metal strips, forming a flexure pivot. This type of suspension—also termed a cross-blade hinge—is well known, the important property in this case being that it gives a frictionless suspension. Movement of the pendulum is restricted by a double-acting air dashpot, which limits its swing to ±20 min and takes the weight of the suspended part when the instrument is being moved about.

The optical stabiliser is designed as a completely self-contained entity, which can be replaced by a spare one, adjusted at the factory. It has, however, also been designed to stand up robustly to the trials of actual use. For instance, a factor of safety of 350 is quoted for the stresses in the strips forming the flexure pivot. The pivot is designed to have precise rotation about its axis with a repeatability of 1 second of arc for which consistent accuracy is claimed between limits of temperature of −30 deg. and +50 deg. Cent. The material of the strips has a constant modulus of elasticity over a slightly greater temperature range; modulus control, combined with great strength, are needed to give low drift of the zero position. The makers also point out that the method of compensation does not depend on mechanical magnification of the residual tilt of the instrument, but the correction is purely optical, which has advantages over other methods recently developed on the Continent.

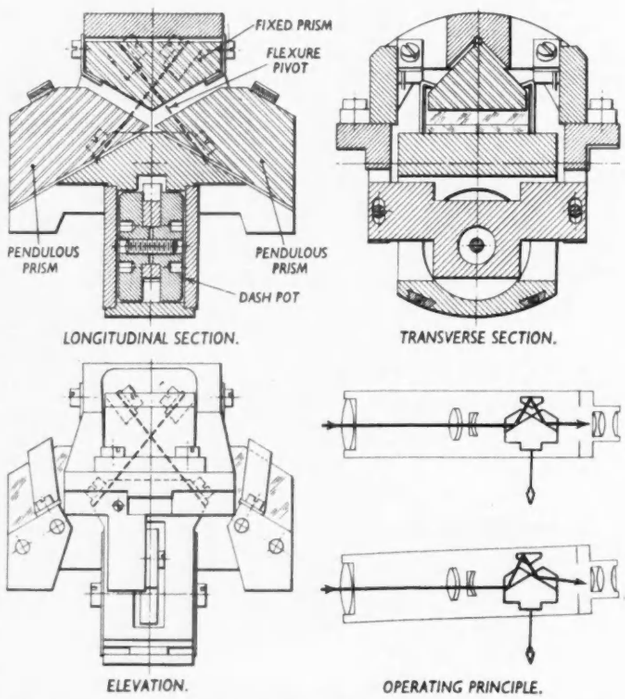
The brief specification of both instruments incorporating the stabiliser is as follows:—

Telescope magnification	×32
Aperture	1⅜in
Field of view	1°20′
Short focusing distance	6ft
Accuracy of stabiliser	1 sec of arc
Weight	6–6½ lb

Extensive field trials have been undertaken, to support the various figures given in this description. An accuracy of 0·02ft per mile is easily attained, it is considered, and by taking the usual care associated with double levelling, an average closing error of 0·004ft per mile can be achieved. Apart from highly accurate work, however, it is considered that the ease and rapidity of using the instrument make it suitable for work where a relatively low standard of accuracy is needed. A point of interest is that the instrument gives an erect and not an inverted image.



Self-setting levels. When setting up these instruments, the bubble in the circular spirit level is adjusted to give approximate horizontality. No further adjustments are needed for accurate levelling



Construction and principle of operation of the "optical stabiliser," or compensating device in the self-setting levels

Technical Reports

The Development of a Variable-Mach-Number Effuser. By J. B. McGarry. Reports and Memoranda No. 3097. H.M. Stationery Office. Price 5s. 6d.—A series of tests was undertaken on a simple, two-dimensional, variable Mach number effuser, or nozzle, designed for the range of supersonic flows up to Mach number 3·0. The performance of the nozzle was assessed from the magnitude of the percentage variation in its exit Mach number distribution. Studies of the effect on the performance of alterations to the position of the nozzle-block pivots and other geometrical features were made. A final build of nozzle was developed which produced flow of a uniformity sufficient for intake and engine model testing over the Mach number range from 1·5 to 3·0.

A Flight Technique for the Measurement of Thrust Boundaries and of Drag Due to Lift. By H. D. Rylands, B.Sc., A.F.R.Ae.S. A.R.C. Current Paper No. 405. H.M. Stationery Office. Price 2s. 6d.—None of the existing methods of measuring thrust boundaries is suitable for use with the new high performance aircraft. A new technique is therefore proposed which is acceptable for supersonic aircraft and which will also have many advantages over existing methods for use with subsonic types. Some data on drag due to lift can also be obtained without the need for thrust measurement. Preliminary flight trials on a subsonic aircraft proved very satisfactory.

SHORTER REPORTS

Scholarships for Machine Tool Designers

THE Machine Tool Trades Association (M.T.T.A.) announced last week a scholarship scheme to inaugurate an advanced course in machine tool design at the Manchester College of Science and Technology. The course will be of two years' duration and applicants, between the ages of twenty-one and thirty, will be drawn from the industry's existing reservoir of young designers and also from engineering graduates with practical experience on the shop floor and in the drawing office. There will be ten M.T.T.A. Design Scholarships awarded every year, to the value of £500 each. The M.T.T.A. will meet this by an aggregate sum from its own resources. Ultimately it is hoped to provide one or two further scholarships to enable outstanding students to undertake a year's advanced research.

The curriculum represents an entirely new course in machine tool design. It has been prepared by the College and incorporates many practical suggestions from the industry. The course will commence in September, 1959. Both the industry and the academic authorities are confident that it will not only form the nucleus for a future leading school of advanced machine tool design in this country, but will also play a major part in determining the machine tool industry's long-term development. Details concerning the conditions of application as well as general information can be obtained from The Machine Tool Trades Association.

The minimum qualification for admission is the Higher National Certificate in Mechanical or Electrical Engineering. Students will receive lectures on subjects dealing with performance requirements, design specifications and basic design and calculation data for machine tools; the principles of electrical engineering, especially electronics; hydraulics; vibrations; friction and lubrication; control engineering; properties and behaviour of engineering materials; standardisation; metrology; ergonomics; safety regulations; economics of automation. Design problems concerning machine tool structures, drive elements, slides, slideways and bearings will be discussed, and laboratory exercises, work on actual design projects and visits to the works of leading machine tool firms in the country will complete the syllabus of the course. Lectures will be given by specialists on the staff of the college and by experts from the machine tool industry. The students will also be shown various research projects which are at present carried out in the machine tool laboratories of the College.

It is hoped that by thus combining the efforts of academic teachers and research workers and of industrial design engineers and the industries behind them, it will be possible to keep pace with the rapid developments which are at present in progress and to maintain the position in the machine tool world which this country has held for so many years.

Port of Melbourne: New Steel Handling Berth

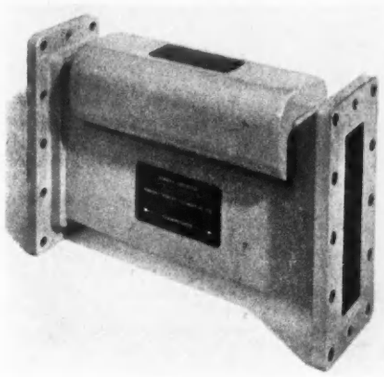
THE prosperity of the State of Victoria, in Australia, depends upon trade which is mainly channelled through the Port of Melbourne. The port handles 97 per cent of the State's seaborne general cargo. To provide for the more efficient handling of iron and steel in the port, the Melbourne Harbor Trust Commissioners have recently constructed a completely mechanised steel handling berth. This berth, the most modern of its kind in Australia, has been tailored-to-measure for Victoria's growing steel trade. The berth was designed primarily for the efficient handling of steel products, but it is also used for handling pig iron and scrap. Four 6-ton electric level luffing wharf cranes are provided on the wharf apron. Running on tracks within the specially designed shed are travelling overhead 6-ton shed cranes in six of the seven bays. An unusual feature of the shed design is that the cranes run transversely across the shed and not longitudinally. The shed cranes serve the dual purpose of receiving iron and steel from the wharf cranes and loading motor trucks and semi-trailers on the roadside at the rear of the shed. For this reason the tracks extend beyond the front and rear of the shed. The cranes can be fitted with magnets for handling pig iron and scrap or with hooks for handling other kinds of iron and steel. Two of the cranes can be operated with single hooks and the other two can be fitted, when required, with two hooks each to facilitate the handling of steel in lengths longer than the opening of the ship's hatch. When two hooks are used on the one crane they are attached to the steel bar in the ship's hold, and can be operated independently of each other to tilt the bar—which may be 45ft or more in length—into a vertical position, so that it can be lifted easily through the hatch. The bar can then be lowered into a horizontal position to be placed on the wharf. Four of the shed cranes can also be fitted with magnets when required.

The pattern of discharge from a ship is by wharf crane from ship to wharf, transfer to the hooks or magnet of the overhead shed crane for conveyance sorting within the shed, and then direct to road transport again by overhead crane. The shed has been so dimensioned and designed that a newly arrived ship may discharge into it while bays remote from the discharging area are still being cleared. At the rear of the shed is a 100ft wide roadway, which gives motor trucks and semi-trailers plenty of "elbow-room" for rapid movement of goods, and beyond this roadway is a modern office and amenities building of contemporary design. The completely mechanised handling of iron and steel at this berth is resulting in the more rapid movement of cargo and the quicker turn-round of vessels, and helps in keeping terminal costs to a minimum. The centralisation of iron and steel handling in the Port of Melbourne at this modern, mechanised berth is freeing for other uses four berths which, in past years, have been used almost full time in handling these cargoes. This is a graphic illustration of the fact that mechanisation is virtually the equivalent of extra berths in the port. In its mechanisation, cargo accommodation, offices and amenities for port workers, the new berth offers facilities of the highest world standard.

In 1957, vessel entries in the port totalled nearly 2500 with an aggregate gross tonnage of 15,391,025 tons. These ships wore the flags of twenty different nations and carried 8,197,811 tons of cargo. Since the end of World War II the Port of Melbourne had been expanding at an unprecedented rate to keep abreast of the great economic development in Victoria. This new investment has taken the shape of new dock systems, new berth and cargo transit sheds, more intensive mechanisation, the progressive modernisation of existing facilities and enlarged and improved services. The port covers an area of 20 square miles and its 105 berths in commercial service have a combined length of 12½ miles. Thirty berths are served by electric level luffing wharf cranes of 3, 6 and 7½ ton capacities, and sixty-three berths have cargo transit sheds offering nearly 50 acres of covered cargo accommodation space. Existing sheds have individual areas of up to 60,000 square feet and three now in construction at Appleton Dock will be of 90,000 square feet each. In addition to the port's wharf cranes, other mechanical cargo handling aids include heavy lift cranes—40-ton diesel-electric floating and 60-ton shore-based—and transporters, conveyors and overhead shed cranes at special berths, along with some 500 units of mobile mechanised cargo handling appliances, including fork-lift trucks, timber straddle trucks, front end loaders and mobile cranes.

Ferrite Isolators

THREE series of ferrite isolators for use in the main microwave communication bands are being made available to the electronics industry by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex, as part of a programme covering the development and manufacture of specialised components which are not readily obtainable from other sources. The ranges for which orders can be accepted at present are Series "RD 103" for the 4000 Mc/s band, Series "RD105" for the X band and Series "RD106" for the 2000 Mc/s band. The isolators make use of the property of resonance absorption in a ferrite material developed in the Marconi Research Laboratories. They permit



Marconi "RD 106" ferrite isolator for the 2000 Mc/s band. The direction of transmission is shown by the arrow on the label

propagation of energy in one direction but absorb energy, reflected at any mismatch, travelling in the opposite direction. This neutralisation of the effects of delayed reflections from distant mismatches in long transmission lines reduces distortion, and improves the performance of mass-production microwave antennæ terminating long feeders.

It is stated that the use of the isolators enables the performance of microwave links to be improved so that a substantially increased number of communication or colour television channels can be carried. Avoidance of frequency-pulling effects due to varying load impedances in test bench work by using the isolators obviates the insertion of at least 10 dB of attenuation.

The gyro-magnetic effect of certain ferrites which leads to the Faraday effect can be used in various ways for microwave circuits. The non-reversible resonance absorption due to precession resonance of spinning electrons is the principle on which the design of this series of isolators is based. They are insensitive to temperature changes arising from external or internal heating over a wide temperature range—a property achieved by the development of the ferrite material in the Marconi Research Laboratories and by special configurations for which a patent application has been made. The inserts (ferrite and ceramic) are proof against humidity.

Waveguide flanges of specified and approved types may be fitted as required. The permanent magnets are stabilised to such an extent that reasonable treatment of the isolator as far as ferrous tools, &c., are concerned has no adverse effects on the performance. Unless a special finish is requested, the interior of the waveguide and the flange faces are silver plated. Manufacture to fine limits gives a tolerance of the standing wave ratio of 1·05 to 1·02 or better, so that equipment in which the components are used will conform with C.C.I.R. recommendations.

The Enfield Town line at Seven Sisters: 82-ton up-line span being lowered into position by two 45-ton steam cranes. In the background can be seen the down-line portion of the old bridge which was replaced during the second week-end possession

82-Ton Prefabricated Railway Bridge

EXTENSIVE reconstruction of bridges on the Enfield Town line of the Eastern Region of British Railways is being carried out as a preliminary stage in electrifying the line. Fifteen underline bridges are being reconstructed on this 10-mile stretch of line in readiness for the electric services which are scheduled for 1960. One of the most interesting jobs to have been carried out so far was the reconstruction of bridge No. 1930 which carries the Enfield Town line over Seven Sisters Road just south of Seven Sisters station.

The original bridge, of wrought-iron construction, was built over eighty years ago. Although the actual reconstruction was completed during two week-end possessions in December, preparatory work commenced in May and involved the erection of double rows of steel trestling and the insertion of longitudinal steel way-beams to take the weight of the existing bridge whilst strengthening of the abutments was carried out and bearings prepared for the new structure.

The two sections of the new bridge (one supporting each line) are each steel box beams, and were fabricated in Glasgow; each one measures 87ft long by 11ft wide giving an effective span of 79ft. The steel work of each span weighed 64½ tons; waterproofing, tiling and concreting, carried out at Manor Road Yard, Stoke Newington, made the weight 82 tons.

After being given possession of the line on 5 p.m. of the Saturday, the track and temporary way-beams were removed from the up line. It had previously been established that platforms would be required to support two 45-ton steam cranes, so during the previous week railway staff had reinforced the embankment and placed timber cribs for the outer outriggers of the cranes. A concrete distributing beam, weighing approximately 10 tons, was laid partially on the ballast and partially on the new concrete abutment for the inner outriggers immediately after the removal of the track.

Oxy-acetylene equipment was then used to cut the bridge floor longitudinally along the centre and along one main girder of the old bridge to allow half of the floor and one main girder to be lifted out and removed by rail. The temporary way-beams were then removed by a road crane and the new up line span was brought on to the remaining portion of the existing bridge on a 100-ton flat wagon and lowered into position by the two cranes, as shown in the illustration, this latter operation being effected during the early hours of Sunday morning.

Once the bridge was in position on its new bearings the permanent way was reinstated, ballasted and temporary timber way-beams placed over the abutments to enable the waterproofing and drainage to be completed. The whole operation was repeated on the second week-end with the positioning of the down line span. Weather conditions were extremely poor when this work was done, but it was nevertheless finished in the stipulated occupation period. Sir William Arrol and Co., Ltd., was the main contractor for the work, which was carried out under the direction of Mr. A. K. Terris, M.I.C.E., Chief Civil Engineer, Eastern Region.

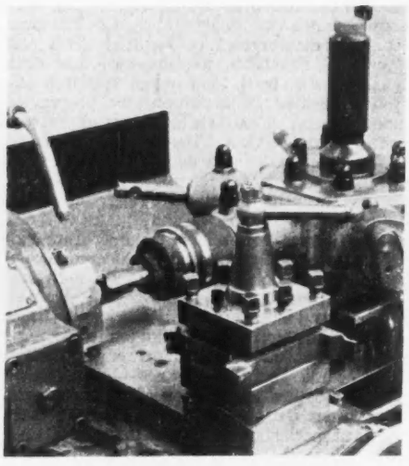
Tapping Attachment

THE tapping attachment shown in the accompanying illustration is being made in two sizes by Alfred Herbert, Ltd., Coventry. The smallest of these "Saftap" attachments will tap holes from 2 B.A. and the largest holes up to 1¼in B.S.W. They can be used either on drilling machines or lathes having a reverse to the spindle, and can be supplied with either straight or Morse taper shanks.

In these attachments the drive is transmitted through a multi-plate friction clutch and the main spindle of the tapper, which carries the collet chuck, runs in needle-roller bearings. The tension on the clutch plates on the smaller model is applied by a rectangular-section coil spring which encircles the main spindle of the tapper. On the largest size the tension on the clutch plates is applied by Belville washers. Pressure on the clutch plates can be adjusted by a knurled ring on the body to produce slip under any predetermined cutting load which will vary according to the size of the tap.

The tap is located, from its shank diameter, in a spring collet to keep it in line with the axis of the machine spindle. The tap is prevented from rotating in this collet by locating the driving square of the tap in a square hole, and the collet is fitted into the chuck, which has a driving peg to engage and drive the tap. A locking nut on the front of the chuck retains the collet and locks the tap in position. The endwise movement of the spring-loaded collet chuck permits the tap to follow its own pitch when tapping to prevent stripping or thinning the cut threads.

When the attachment is used on a drilling machine, holes can be drilled and tapped from the same setting by fitting a quick-change sleeve to the taper shank of the "Saftap" and a similar sleeve to the drill. The drill and tapping attachment can be quickly interchanged.

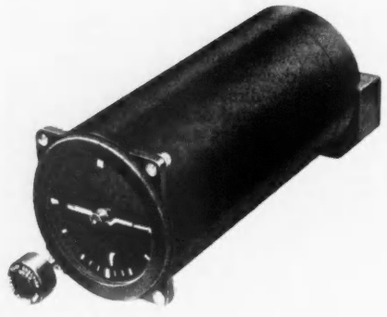


Tapping attachment on a turret

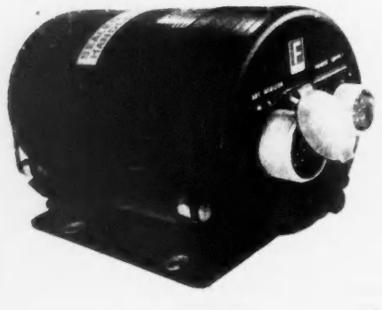
Artificial Horizon with Stand-By Facility

AN alternative supply from the aircraft battery may be used for stand-by operation of the Standby Artificial Horizon System which Ferranti, Ltd., Hollinwood, Lancs, is supplying for Boeing 707-436 aircraft ordered by the British Overseas Airways Corporation. British European Airways has already adopted the system for "Vanguard" aircraft, and B.O.A.C. for the "Comet."

Components of this system, which meets British Air Registration Board requirements, are the 3¼in "FH7D" artificial horizon and the "F13" combined control/inverter unit. Normally the system operates from a 115V, 400 c/s, single-phase a.c. supply, but in an emergency it will continue to operate (or start up and operate)



Artificial horizon to be installed in B.O.A.C. Boeing 707-436 aircraft



Control inverter unit for artificial horizon. Changeover to d.c. operation is automatic if a.c. supply fails

from a 21V to 29V d.c. supply. Changeover to d.c. operation is automatic on failure of the a.c. supply, and when running on d.c. the required 115V, 400 c/s a.c. input is derived from a transistorised static regulator and transistorised static inverter in the control unit.

The control unit also includes the automatic changeover circuit and a control section, with a relay which provides a supply for erection of the gyro in the artificial horizon at a rate of 120 deg. a minute as compared with the normal 3 deg. a minute. This facility is brought into operation by means of a push-switch on the horizon.

A power failure indication circuit in the control unit causes a flag warning to be shown on the horizon when power is cut off, and also ensures that on loss of supply the outer gimbal of the horizon settles at the vertical datum.

Artificial horizon and control/inverter unit are both hermetically sealed and filled with an inert gas comprising 80 per cent helium and 20 per cent nitrogen. Overall dimensions of the control unit are 8·22in by 5·12in by 4·69in, and it weighs 6·7 oz. Normal working temperature range is from −20 deg. to +55 deg. Cent., but it will operate from −40 deg. to +70 deg. Cent. without derangement. Power output is 15W, or 35W for short periods.

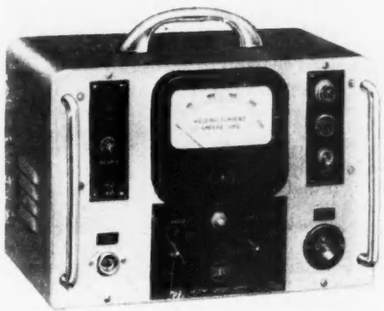
Welding Current Measurement

A WELDING current meter, designed to measure short pulses of heavy current, as encountered in resistance welding machines, has been introduced by Hirst Electronic, Ltd., Gatwick Road, Crawley, Sussex. Standard models of this "H.E.D." welding current meter have a minimum reading of 500A and a maximum of 100,000A in six ranges selected by a scale factor switch. The minimum pulse time is 10 milliseconds, but pulses down to 2 milliseconds can be measured if several welds are repeated. Consumption of the meter on a 230V, 50 c/s input is 25W, and it can also be supplied for operation on 110V.

A standard split and hinged air-cored toroidal current transformer which will clamp over any bar up to 4½in diameter, is normally supplied. Fixed ring type transformers can also be provided for building into individual machines and any number can be switched to a meter.

The output from the transformer is integrated electronically and the integrated voltage is applied via a charging diode to a capacitor, which is thus charged to the peak value of the integrated waveform. A high-impedance valve voltmeter is used to measure the charge on the capacitor. By this method of operation readings are stored in the capacitor and can be taken minutes after the weld has been made. The time over which the signal from the toroid is integrated is variable so that r.m.s. readings can be taken if desired.

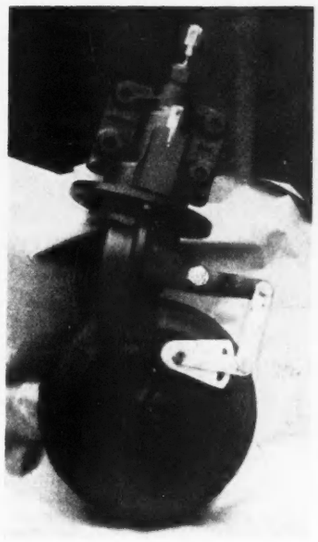
The instrument can be used with welding machines employing synchronous, non-synchronous and energy storage controls. Where phase shift heat control is incorporated, a correction factor must be used to obtain accurate quantitative evaluation of r.m.s. current but direct readings serve for checks of consistency. No interruption of welding operations is involved in using the meter. Current transformers may be clipped to any part of the welder secondary circuit and left permanently fitted to the machine.



The "HED" meter for current measurement in resistance welding. (Dimensions 12in by 7in by 8in)

Braked Castor

A 1-TON capacity castor incorporating a brake and directional locking means which is now being made by Autoset (Production), Ltd., Stour Street, Birmingham, is illustrated below. The castor is fitted with tapered roller bearings in the swivel housing and in the wheel hub. Its brake is operated by a rod passing through a bore in the pivot spindle, and this rod actuates a



Castor incorporating an expanding brake and means of directional locking

bell crank lever. The bell crank lever, through an auxiliary lever, operates expanding brake shoes in the wheel. Brake shoe clearance is set by adjustment of the auxiliary lever in the curved slot of a quadrant.

The direction of the wheel, in respect to the swivel housing, is set by the lowering of a spring-loaded bar, at the side of the housing, into one of eight holes spaced round a circular plate at the top of the wheel fork assembly.

Control System for Automatic Weighing

A NEW control system for the automatic weighing of materials in fields such as food processing and chemical manufacture has been developed by E.M.I. Electronics, Ltd., Hayes, Middlesex. The equipment for the new system, which is known as "Emiway," can be fitted to most kinds of scales. It enables any number of weighing operations to be controlled accurately and, when applied to a suitable process, it can form the basis of a fully automatic control system.

Briefly the facilities provided by this system are as follows. The weight of materials to be discharged from storage bins or hoppers can be set-up on dials or programmed on punched cards or tape. Automatic switching from fast to slow feed is provided. The system ensures accuracies in the region of 1 part in 1000 of the 360 deg. of a scale dial movement. Automatic weighing of containers enables the tare weight to be recorded before material flow starts, and ensures that the net weight remains constant. When required, remote indicators can be provided, enabling the weight on the scale dial to be displayed simultaneously at any number of other points. Data such as time, date, type of material, source, destination and costs can be recorded automatically for stock control and accounting purposes, by electric typewriter or teleprinter, card or tape punch.

The basic equipment consists of five units: (1) a scale transducer; (2) analogue-to-digital-conversion unit; (3) print-out decimal-to-binary-conversion and control unit; (4) power unit; and (5) remote display.

A transducer is fitted on the back of the scale, which is coupled directly to the pointer shaft. Remote from the scale, in any convenient location, is the main cabinet, including the servo equipment, digitiser (which converts the shaft angle to an unambiguous digital code representing the angular displacement) and other units. Decoding of this digital information is done by an electric decoder, which works at very high speed and, unlike the relay type of decoder, can accurately follow the rapidly varying movement of a scale pointer in either direction.

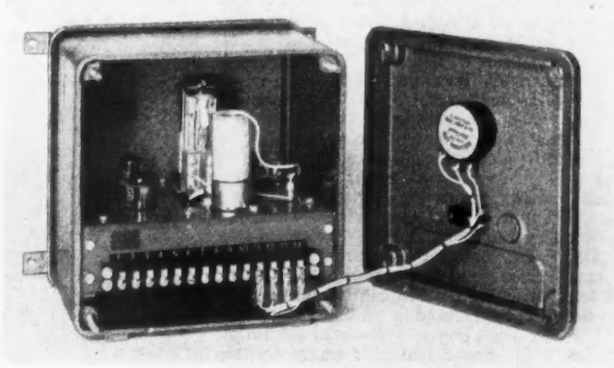
The output can be continuously displayed, and by means of co-incidence circuits, the decimal output from the decoder can be "caught" at a predetermined setting, and made to control, say, the feeding mechanism of the material being weighed. An unlimited number of such circuits can be added and set as required to perform a number of different functions at different weights —for example coarse and fine feeding of several different materials on a cumulative system.

A delay network may be added which assures that the scale will come to rest before further action, such as print-out or adding another ingredient to the weight, can take place. In the print-out equipment, the decimal outputs are scanned, in sequence, the scanning system stopping momentarily on each digit to be printed, allowing sufficient time for a teleprinter to print that figure before searching for the next digit.

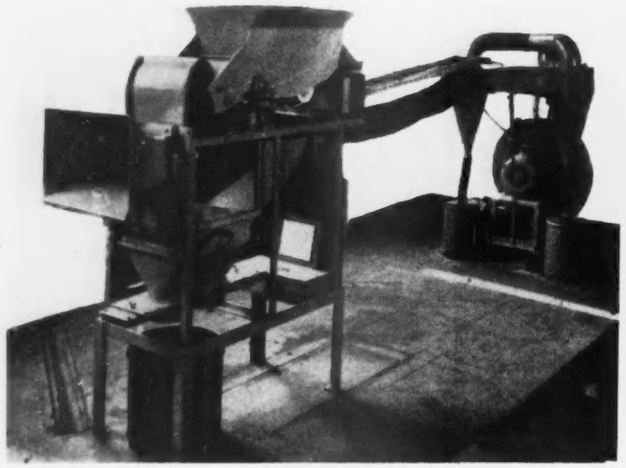
Electronic Process Timers

A NEW range of electronic process timers, Series "PCT.1," introduced by Lancashire Dynamo Electronic Products, Ltd., Rugeley, Staffs, consists of six basic models. The timing periods covered are (*a*) 0·1 to 1·5 seconds; (*b*) 0·3 to 5 seconds; (*c*) 1 to 15 seconds; (*d*) 3 to 50 seconds; (*e*) 10 to 150 seconds, and (*f*) 30 to 500 seconds. Each main time range is sub-divided into long and short ranges selected by a switch. A continuously-variable control, calibrated directly in seconds, is provided for setting the required time interval. The units are stated to have a repeat accuracy of ±1 per cent on a stable supply, and variations in supply voltage of −15 per cent to +10 per cent will not cause more than ±5 per cent change in the set time interval. The relay has one pair of normally-open and one pair of normally-closed contacts, allowing the control of two separate circuits in the opposite sense.

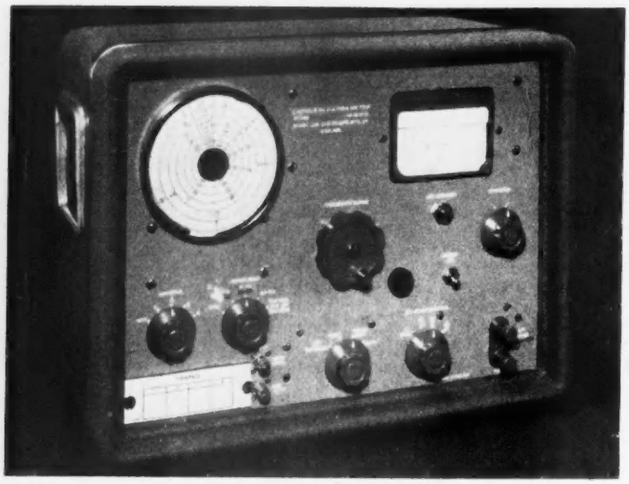
The process timers are housed in a cast light alloy case designed for wall or base-mounting. Sealing arrangements on the detachable covers exclude dust and moisture. The timers are designed for 200/250V or 110/115V, 50/60 c/s single-phase supplies. Approximate dimensions of the unit are 9¾in by 4¾in by 5in.



Process timer case opened, showing connections to switch and time-setting potentiometer, and terminals for power supply and external circuits



Separator for blast-furnace slag as assembled in the B.I.S.R.A. laboratories



Deviation meter for f.m. transmissions, with crystal locking to give freedom from microphony

Separator for Blast-Furnace Slag

THE problem of controlling the porosity of blast-furnace slag is one which has been for some time engaging the attention of the British Iron and Steel Research Association. It is a problem, B.I.S.R.A. says, which can be approached in two ways: attempts can be made to regulate the number of bubbles trapped in the cooling and solidifying slag, or the porous material can be separated physically from the dense material after the slag has solidified. Both approaches are included in the current investigation, and B.I.S.R.A. has just prepared a progress report dealing with its work on the separation problem.

When the research began it was known that there was no significant chemical difference between dense and porous slag from the same ladle. It was realised, therefore, that a separation process would have to depend on the physical properties of the slag particles and, as even dense slag does not command high prices, that the method used for separating the slag must be as cheap as possible. The chemistry department of B.I.S.R.A. has developed a slag separator which makes use of the winnowing action of an air stream. In this equipment, which is illustrated herewith, the air-cooled slag is first crushed and graded fairly closely to size, the crushed slag then being allowed to fall under gravity through a transverse air stream. The particles are blown sideways, the lighter and more porous ones further than the denser ones which have greater inertia. An upright blade placed in the path of the fan-shaped stream of falling slag particles directs the lighter and denser fractions into separate hoppers. The amount of separation depends, of course, on the distribution of bulk density in the slag. The B.I.S.R.A. equipment is portable and has few working parts.

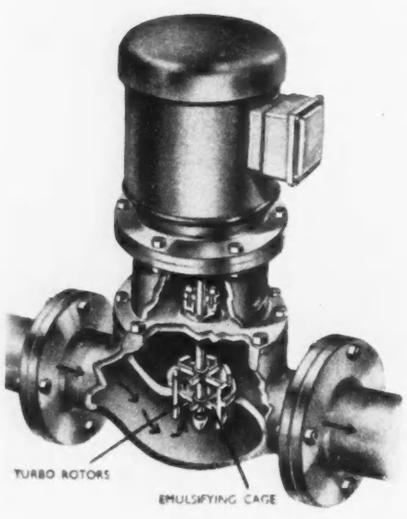
Barge-Mounted Excavator

THE North-Western Division of British Waterways has in use a barge-mounted excavator for general dredging, and the clearance of shoals. The excavator is a standard "Hydra-Digga" made by J. C. Bamford (Excavators), Ltd., rigged as a back-acter. As its name implies, this excavator is entirely hydraulic in operation. It is mounted on a pontoon, measuring 30ft by 12ft by 2ft 6in, constructed of angle-iron framing and steel plate, and with a frame carrying the excavator. Stability during excavation is achieved by four spuds, one at each corner, which are operated hydraulically, and can be lowered to a depth of 4ft, or give a downward thrust of 2 tons. Each spud has a horizontal "foot" 4ft long, at its base, which can be rotated from the deck and then locked in the position wanted. A Fordson diesel engine is mounted amidships, driving a 25 g.p.m. hydraulic pump for the 1500 lb per square inch hydraulic system. The bucket of the digger has a 180 deg. slew, can dig to a depth of 13ft, and load to a height of 10ft 6in.

Continuous Pipeline Mixer

MIXING of large volumes of liquids and pumpable fluids generally involves the installation of tanks or storage vessels and attendant equipment. However, the floor space normally required is greatly reduced with the introduction of a new unit which efficiently mixes fluids as they flow through a pipeline and thus dispenses with the need for agitating vessels. This unit, the "Thrumix" continuous pipeline mixer, of which we include a sectioned view, has been developed by William Boulton, Ltd., ceramic and process engineers, Providence Engineering Works, Burslem. It is manufactured in a range of sizes from 1in to 6in bore, and can be made of cast iron, stainless steel or the usual constructional metals.

The principle employed in the "Thrumix" mixer is a very high degree shear and an easily controllable degree of recirculation. Small horsepower motors, ranging from ¼ h.p. to 2 h.p., are required, depending on the requirements, and represent an economy in power. Either a standard stuffing-box or mechanical seal can be fitted and for low-viscosity materials the throughput ranges from 14 to a maximum of 400 gallons per minute. The mixer, owing to its simplicity, is suitable for continuous processes where an agitator tank is a disadvantage. Applications of the mixer include the combining of liquids, liquids and gases, and liquids and solids; the aeration of liquids and gas absorption; the adding of lime and starch; the mixing of flocculation agents for thickening; and sludge conditioning. Two models are now in production, the first having a fixed degree of recirculation, and the second having means for axial movement of the stator cage, which allows varying degrees of recirculation and controlled shear and, thus, different degrees of mixing.



Sectioned view of "Thrumix" continuous pipeline mixer

F.M. Carrier Deviation Meter

AN addition to the range of Marconi Instruments direct-reading f.m. deviation meters is the TF 791D, suitable both for communication and broadcast systems. The meter has four deviation ranges of 5, 25, 75 and 125 kc/s full-scale, and a modulation frequency range of 50 c/s to 35 kc/s. The calibrated carrier frequency range extends from 4 to 1024 Mc/s. Crystal lock facilities bring the internal f.m. noise down to − 55 dB relative to 5 kc/s deviation, giving a freedom from microphony which allows reliable measurement of f.m. hum and noise in transmitters for v.h.f. sound broadcasting and mobile close-channel working. To aid measurement of asymmetric modulation, positive or negative deviation is displayed at the turn of a switch without the need for retuning.

The local oscillator operates on harmonics over six of its eight bands; this avoids the danger of frequency pulling at the higher frequencies and ensures positive locking at any harmonic frequency of crystals within the relatively small fundamental range 2 to 10 Mc/s. Crystals, up to a maximum of four, can be supplied to suit any specified carrier frequencies, and are selected in the instrument by a switch.

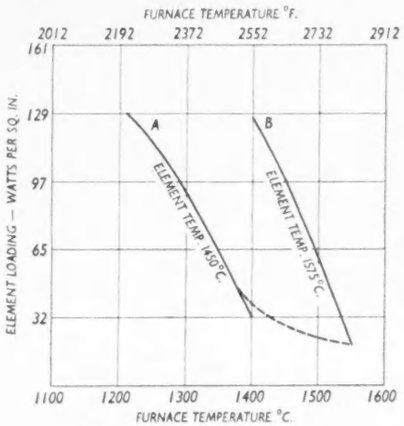
The instrument is basically an f.m. receiver using a counter-type discriminator for high stability; its demodulated output energises a meter calibrated directly in deviation, and is also available externally at a separately buffered outlet for aural monitoring or measurement of very low deviation.

The f.m. input is applied to a frequency changer comprising a tunable local oscillator and a crystal mixer. The resultant i.f. signal is amplified and then converted to a square wave by a limiter circuit. From the square wave, unidirectional pulses are produced by rectification and differentiation. The pulses are integrated to give an output of amplitude proportional to deviation and of the frequency of the original modulation.

A high order of measurement accuracy is maintained by the provision of a crystal-controlled deviation standard: when the instrument is switched to "set deviation," the r.f. and first i.f. stages are disconnected and the remaining i.f. stages generate a crystal-controlled test signal of constant effective deviation against which the meter scale may be standardised.

Electric Furnace Elements

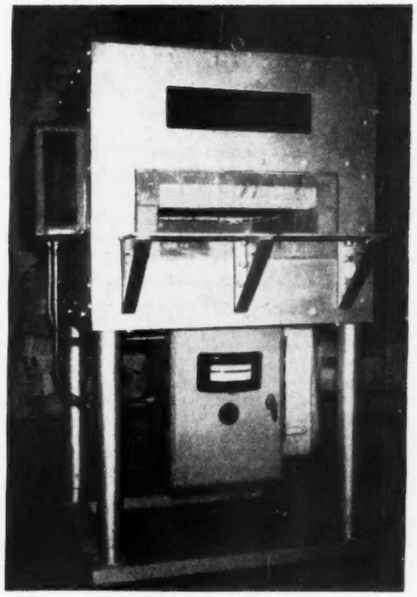
AT an exhibition arranged by the Morgan Crucible Company, Ltd., Battersea Church Road, London, S.W.11, and held in the Birmingham show rooms of the Midlands Electricity Board, there were recently shown a number of applications to industrial furnaces of the "Crusilite" furnace heating elements. These elements, of silicon carbide, have for some time been made by the Morgan Crucible Company, Ltd., with terminal caps at each end; but a more recent design has both the electrical connections at one end. This new design



Loadings of "Crusilite" elements

simplifies installation in a furnace as the elements can be hung from the roof, projected up through the floor or in through the walls of the chamber. The spiral at the upper part of the element provides the hot zone, and the elements are made in a number of sizes with diameters from 18mm to 35mm and hot zone lengths from 250mm to 400mm respectively. Over the range of lengths and diameters the approximate resistance per 1000mm of hot zone ranges from 2·75 ohms to 1·5 ohms, the resistance tolerance being ±15 per cent. Another design of similar element, which can be mounted vertically to provide a cylindrical chamber and used for heating small laboratory crucibles, has an inside diameter of 65mm with a hot zone length of 150mm, its resistance being 4·5 ohms.

Conventional double-ended elements are made by the firm in a range of diameters from 10mm to 35mm with hot zone lengths from 180mm to 1000mm, and having approximate resistances from 2·2 ohms to 0·24 ohms per 100mm of hot zone. It is stated that the elements age at a comparatively low rate and require a reserve voltage of only 40 per cent, which can be provided in an installation by a variable resistance or a tapped transformer. In some applications, such as forge furnaces, the elements can be supplied directly from the main power lines. Intermittent switching operations do not in any way adversely affect the life of these elements, and when necessary they can be renewed without waiting for a furnace to cool down. The resistance/temperature characteristics are the same for all types of "Crusilite" elements, and the representative watt loading curves for various furnace temperatures are shown in the graph we reproduce. The loadings indicated by curve *A* should preferably not be exceeded in production furnaces, though for furnace temperatures of 1375 deg. Cent. and higher the dotted line provides a reasonable compromise. In research work elements may be used up to the amounts shown on curve *B*.



Slot furnace for forge shop with a temperature range up to 1400 deg. Cent.

Amongst the furnaces using the elements which were shown in the exhibition was the slot forge furnace illustrated on this page. The furnace is made by the Furnace Construction Company, Ltd., 48, Smith Street, Birmingham, 19, and has a temperature range up to 1400 deg. Cent., with an output capacity of 150 lb per hour. It has a 4in high, 24in wide slot, with a 21in deep hearth. Of heavy mild steel plate construction, with a high-quality refractory hearth and guard tiles, this furnace is mounted on internally sprung legs to reduce the effects of vibration in a forge shop. The indicating control instrument mounted below the furnace has a range of 0 deg. to 1600 deg. Cent., and through a contactor relay maintains the temperature at a predetermined setting.

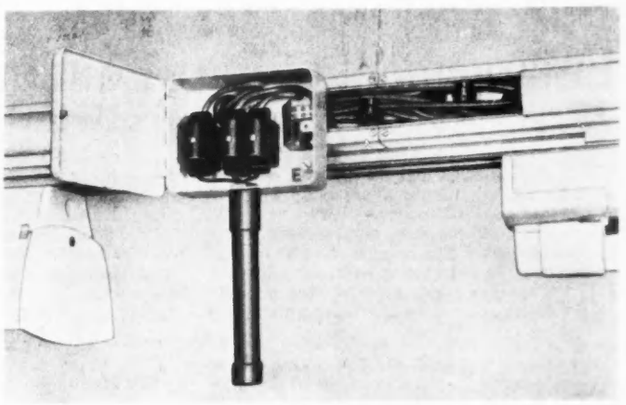
The elements were also shown applied to a small muffle furnace for laboratory use at temperatures up to 1350 deg. Cent., and a small heat-treatment furnace for temperatures up to 1400 deg. Cent. Two small experimental furnaces were temporary assemblies of high-temperature insulating bricks cut to required shapes, and which could be dismantled at the end of an experiment and the parts reassembled for other purposes when again needed.

Adaptable Trunking for Medium Power Circuits

WE illustrate part of an installation typifying "Power Line" trunking—a system which enables moderately rated power circuits and communication networks to be installed alongside existing lighting wiring, each of the three systems being in completely separate wiring runs.

The new trunking is made by Crompton Parkinson, Ltd., Aldwych, London, W.C.2, and is primarily designed to be attached to the company's "New Line" trunking, on one or both sides; but it can also be attached to walls or benches as an independent installation. The fact that the cables are merely placed into the trunking with no "drawing-in" makes it a simple method of bringing electrical power and/or communication networks to the bench or machine tool.

Two of the folds which contribute to the strength of existing "New Line" trunking also serve as clamping surfaces for the "Power Line" trunking, which takes the form of a channel, made in 15ft, 9ft and 6ft lengths from 16-gauge rolled steel. Galvanised finish is standard, to give reasonable protection from moisture or damp atmospheres. A screwdriver is the only tool required during the installation. Clamping plates, riveted to the channelling during manufacture, are spaced at intervals of 3ft 6in and the



"Power line" trunking with snap-on cover removed to show line taps and cables. With this system moderately rated power circuits and communications circuits can be installed alongside existing lighting wiring

action of tightening the screws in these plates interlocks, secures and makes earth continuity contact with the supporting lighting trunking.

Cable supports, which are pressed out from the clamping plates, protrude into the channelling and are fitted with plastic sleeves to protect the cables. As many as eight 19/0·064in P.V.C. cables, for example, can be accommodated on the cable supports. Robust line taps for tap-off conductors up to 7/0·036in are available, as illustrated; they are similar to those used for lighting circuits in "New Line" trunking. Pressed steel fuse boxes, finished in grey stoved enamel and incorporating Reyrolle "Pullcap" fuse units, complete with h.r.c. cartridge fuses (5A to 30A), can be fitted to any point on the trunking. Protective flashguards are provided on the fuseholders. Installation is simple; a catch on the rear of the box is slipped over the lower lip of the channel, and screws accessible from inside the box tighten the catch. The box can accommodate flexible or rigid conduit or, through suitable glands, S.W.A. cable. The down drop conduit will clear any lighting fittings in the Crompton Parkinson "New Range" series. Earth bonding plates are supplied for use between lengths of trunking and snap-on plastics covers are provided to close the entry against dust and dirt, &c. Heavy-gauge, cadmium-plated, steel end plates are supplied for the ends of runs—1¼in knockouts being standard for these.

Extensions can be made to the services by removing the plastics cover strip, inserting the necessary line taps, attaching a terminal box and replacing the cover strip. Existing boxes may be moved to new positions, leaving the original line taps in position to ensure continuity of insulation of the cables.

Hydraulically Operated Rock Drill Feed Leg

A ROCK drill leg which is operated hydraulically has been introduced by Holman Brothers, Ltd., Camborne, Cornwall, under the trade name "Hydroleg." This feed-support unit for rock drills functions in a similar way to the familiar compressed air operated leg, and it can be used to advantage where rotary electric drills are in service and there is no supply of compressed air. In such cases the supply pressure water which is usually available for dust control purposes can be tapped off to work a hydraulic leg.

In the "Hydroleg" the pressure water hose is attached to a twist grip valve through which the water passes through a hollow piston rod to apply pressure beneath the piston head. The setting of this valve enables the adjustment of the drill feed pressure to be maintained within very fine limits. When the limit of feed is reached, and it is required to retract the leg for re-positioning, the control valve is closed and then, on a lever being depressed, the water beneath the piston head is vented through the foot of the feed cylinder close to the ground. The legs are made in two sizes with feed lengths of 39in and 52in respectively and work with water pressures from 60 lb to 150 lb per square inch.

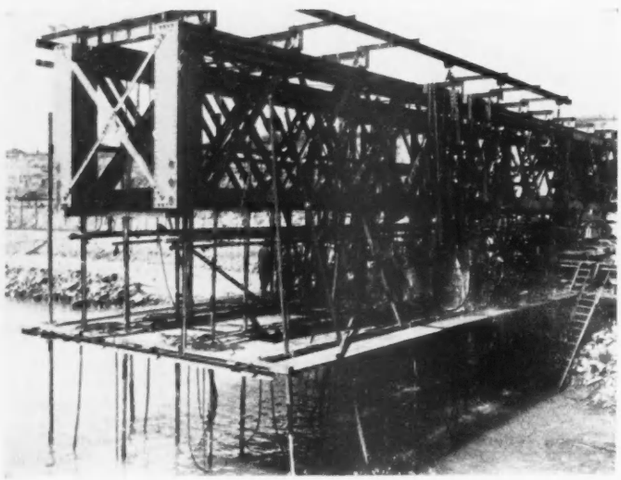
Enlargement of East London Harbour

BY OUR SOUTH AFRICAN CORRESPONDENT

THE turning basin and the harbour entrance at East London harbour are being widened, and two new commercial berths as well as a tanker berth are being built, all work being done departmentally by the South African Railways. The old turning basin dates back to 1935; it enabled the largest ships then in service on the South African route to be turned round and docked safely in this river port. But some of the larger ships are now too big for it.

Work on widening the turning basin from 970ft to 1200ft was commenced during March, 1957. When completed, two additional commercial berths will be available on the west bank, with a 50ft clear space behind the quay wall, on which a single rail track will be laid to enable ships to off-load with derricks direct into railway trucks. The future tanker berth will be built at the easterly end of the widened turning basin. Good progress is being made with the rock excavation. Approximately 50 per cent of the total dry excavation work had been completed after twelve months' work.

The first illustration shows an improvised drill carriage used for underwater drilling. It consists of a discarded Cape Government Railways bridge span, 100ft long, running on two standard 3ft 6in gauge tracks, equipped with three 600 cubic feet per minute air compressors driving eight large drills which drill 2½ in diameter holes to a depth of 42ft, L.W.O.S.T. These holes are then charged by divers with gelignite for blasting.



Improvised drill carriage for underwater drilling

The harbour improvement project is being tackled in two stages. Stage I directly affects the upstream end of the turning basin which has to be widened to a minimum of 1070ft and deepened to 35ft L.W.O.S.T. The new "Pendennis Castle" of the Union Castle Line, which is expected to call at East London during January, 1959, will then present no turning problem. The harbour entrance will also be improved by the provision of a vertically-faced round head at the east pier. At present the round head consists of random concrete blockwork, the toe of which projects approximately 40ft into the entrance channel. Stage II of the work has to be completed early in 1960, when the "Windsor Castle," of 40,000 tons, is expected on the mail schedule.

The second illustration shows work proceeding on Stage I of the excavation. The new concrete quay wall is shown under construction on the left. On the right is the rock wall dividing excavation in the dry from excavation in the wet. Finally, this wall will be blasted away and the incoming water will wash it into the dry excavation which is being made approximately 15ft deeper to retain it.

Stage II embraces the widening of the whole turning basin to 1200ft and the entrance and approach channel to 600ft. The new oil tanker berth will also be built in the new position at the easterly end of the turning basin and, when completed, the existing tanker berth at the upstream end of the turning basin on the west bank of the harbour will be demolished.

Excavation of the widening of East London harbour

Kyle Dam, Southern Rhodesia

THE lake to be formed by Southern Rhodesia's £2,000,000 Kyle dam project sited at the confluence of the Mtlikwe and Umshagashi rivers, will be over four-and-a-half times the country's largest existing lake—the McIlwaine. Its capacity is given as 250,000 m.g. A steady flow of 200 cusecs will be provided by the dam for the irrigation of the low veld, the canal, of capacity 300 cusecs, being designed to supply water to sugar estates in this region. In addition, some 3 m.g.d. will be provided for the development of Fort Victoria. The dam site is located in a narrow V-shaped gorge running between bare granite hills, a few miles to the east of the Zimbabwe ruins.

The contract for the project, which includes a 28-mile long concrete-lined canal, has been awarded to Sir Alfred McAlpine and Son (Rhod.) (Pvt.), Ltd., who will be associated with the firm of Concor Construction (Pty.), Ltd. A new company—McAlpine and Concor (Pvt.)—has been formed to execute the project which has been designed by Monsieur André Coyne, one of the consultants for the Kariba scheme.

The dam will be a thin arch. It will be 23ft thick at the base and 10ft wide at the crest, which will support a 12ft wide road, flanked on either side by a 3ft wide footpath. Water will flow through a free overflow spillway divided into six bays, each with a width of 33ft 4in, and will have a designed high flood capacity of 61,500 cusecs, the rock surface immediately below the dam being protected by a 2ft thick reinforced concrete mattress. The outlet works, sited some 50ft above natural river level, will consist of two 3ft diameter pipes fitted with cone valves, emergency gates and trash racks. The crest length is 900ft and the dam will rise 177ft above the dry season water level. Provision is made in the scheme for a further dam at Bangala, 40 miles downstream.

The dam and canal sites are some 60 miles apart and the first tasks include the building of access roads, accommodation for staff and the clearing of the first stage of the canal strip. Excavations at the dam site should have started this month and will continue until September. Diversion of the river is expected to be completed by April/June, 1959. Some 28,000 cubic yards of concrete must be emplaced by November, 1959, in order to raise the wall to 120ft before the wet summer season starts. The dam and canal are scheduled to be complete by April 30, 1961.

This information about the Kyle dam was sent to us by the Consolidated Pneumatic Tool Company, Ltd., whose plant is in use at the site.

INTERNATIONAL ROAD TAR CONFERENCE.—The next plenary session of the International Road Tar Conference is to be held in Brussels from June 15 to 17 next. A provisional list of the papers to be presented at the conference is as follows: Belgium (main paper), "New Tendencies in the Use of Tar for Road Construction"; France (main paper), "Systematic Investigation on Pitches as a Basis for Road Tars: Recent Results"; Germany (short paper), "Trials of Base Courses made from Hot Mixed Tar and Gravel"; Great Britain (short paper), "Surface Dressing—Improved Techniques"; Netherlands (short paper), "Factors Affecting the Determination of the Rate of Spread of Tar for Surface Dressing"; Poland (short paper), "Emulsification Phenomena of Hydrocarbon Binders under the Influence of Certain Aggregates"; Switzerland (short paper), "Tar Base Courses in Switzerland." The British organising body for the conference is the British Road Tar Association, 9, Harley Street, London, W.1.

Industrial and Labour Notes

Iron and Steel

A production statement issued by the Iron and Steel Board shows that pig iron output in the United Kingdom last year amounted to 13,000,000 tons, which was approximately 11 per cent less than in 1957. The average number of furnaces in blast per week was eighty-nine, compared with ninety-eight in 1957. The final figure for steel production last year (for fifty-three weeks) is given as 19,570,000 tons ; the average weekly rate of 369,200 tons was about 11·5 per cent below the 1957 weekly average. In December steel production averaged 314,000 tons a week, or 21·1 per cent lower than a year earlier.

The Iron and Steel Board estimates that the steel industry will have capacity available this year for an output of 24,500,000 ingot tons. Production at present is running at approximately 18,000,000 tons a year, after allowing for seasonal variations, which is 75 per cent of the current capacity. Provisional arrangements are being made for raw material supplies on the basis of a steel production of 20,000,000 ingot tons this year ; this, of course, allows for a substantial recovery in steel demand. The Board points out that the actual output of steel can be varied considerably at short notice on either side of the provisional estimate according to the actual level of demand experienced.

Scotland's Strip Mill Project

Details as to the financing of the semi-continuous strip mill which is to be built by Colvilles, Ltd., at Ravenscraig, are given in a letter addressed to shareholders of the company by the chairman and managing director, Sir Andrew McCance. The mill will have an initial capacity of 500,000 tons a year, approximately half of which will be hot-rolled strip and the balance light plates. The project includes the installation of cold reduction plant at the Gartcosh works of Smith and McLean, Ltd. (a Colvilles subsidiary), for finishing the hot-rolled strip produced in the semi-continuous mill. The new slabbing mill at Ravenscraig, which is part of the second development stage there, will, after the addition of further ingot heating capacity, be able to produce the slabs required for the strip mill. The duplicate battery of coke-ovens and by-product plant, the second blast-furnace and the additional steel-making capacity also previously included in the second stage of development at Ravenscraig are now to be incorporated in the strip mill project. A third blast-furnace, however, together with additional coke ovens and further steel-making capacity will be required in order to raise the pig iron production at Ravenscraig to a little more than 1,000,000 tons a year and to bring the production of ingot steel to a similar total.

The letter explains that the final form of the strip mill development is subject to the detailed approval of the Iron and Steel Board and the British Iron and Steel Federation. But, following a financial agreement with the Government, the design and layout of the new plant have been discussed with plant manufacturers and these discussions have confirmed that the scheme, as outlined by the company's engineers, is sound and practicable. In considering capital requirements, it has to be borne in mind that the hot strip mill, the cold reduction plant, the further expansion of steel-making capacity and the third blast-furnace, with its related increase in coke and by-product plant, are all additional to previous plans for development and that the former time-table for the construction of additional steel-making capacity at Ravenscraig and the second blast-furnace has been accelerated. The expenditure on all these items, including increased working capital, is estimated at £50,000,000, to be spread over the four years beginning October 1, 1959. In addition, capital requirements for the remaining items previously included in the company's £40,000,000 programme and for routine capital expenditure during the period are likely to amount to £20,000,000, thus making a grand total of £70,000,000. The letter says that the company's existing and accruing resources, even if available banking facilities are taken into account, would be inadequate to finance such expenditure over a period of four years. The Government has, therefore, agreed to provide, by way of a loan repayable by 1978, " such sum not exceeding £50,000,000 as may be required to cover expenditure approved by the Iron and Steel Board in connection with the strip mill development." The maximum amount of the loan is to be reviewed after October 1, 1962, with a view to a reduction in the light of the company's then existing and prospective financial position.

Overseas Trade

The value of the United Kingdom's exports in December was £269,400,000, which was £22,000,000 below the record figure reached in November. For the whole of last year, according to the Board of Trade, the provisional export total was £3208 million, a reduction of 3½ per cent in value compared with 1957. The reduction, it is stated, was almost entirely in the volume of shipments ; on the average, export prices were only fractionally lower than in 1957. The total value of imports in 1958 has been computed provisionally at £3782 million, which was 7 per cent lower than in 1957. Import prices were, on average, 8 per cent lower than in 1957 ; the volume of imports was practically the same. Last year's re-exports were valued at £147 million, an increase of 10½ per cent on 1957, owing principally to a bigger trade in rubber. With a greater fall in imports than in exports last year, the visible trade deficit was reduced to £426 million. That was £187 million less than in 1957 and the lowest annual figure since 1950.

Export Prospects

The January issue of *Export Guide*, a quarterly publication prepared by The General Electric Company, Ltd., suggests that there is likely to be a continuing deterioration in some of the United Kingdom's best overseas markets. But, the publication adds, some countries continue to present favourable opportunities for British exporters, while a few others offer further improved potentialities. The *Guide* sets out the latest available information in this country on the export prospects for thirty-six major groups of manufactured capital and consumer goods in Britain's principal export markets, together with an indication of current economic and commercial conditions in those countries. The conclusion reached is that current prospects are " good " in nine countries, " improving " in six countries, " deteriorating " in ten countries, and " bad " in nine countries.

Lloyd's Shipbuilding Returns

The shipbuilding returns for the quarter ended December 31, 1958, have been issued by Lloyd's Register of Shipping. The work in hand in Great Britain and Northern Ireland at the end of the period totalled 310 ships of 2,234,158 tons. During the quarter fifty-eight ships of 362,180 tons were commenced, seventy-five ships of 390,127 tons were launched, while 75 ships of 440,865 tons were completed. Oil tankers totalled seventy-one ships of 1,064,195 tons and accounted for 47·6 per cent of the total under construction, while tonnage for registration abroad amounted to forty-one ships of 222,150 tons and represented 9·9 per cent of the tonnage being built compared with 40·4 per cent or 825,745 tons in the third quarter of 1958. Abroad, the work in hand amounted to 1132 ships of 7,768,688 tons, of which Germany's share was 1,094,250 tons and that of Japan 995,075 tons. Progress abroad indicated that 342 ships of 1,903,808 tons, 386 ships of 2,048,165 tons and 438 ships of 2,046,453 tons were respectively commenced, launched and completed. Of the total under construction, 3,859,361 tons, or 49·7 per cent, were for export, including 819,190 tons in Japan and 648,361 tons in Germany. Oil tankers, at 268 ships of 4,432,975 tons, represented 57·1 per cent of the total. Throughout the world, excluding China and Russia, 1442 steamships and motorships of 10,002,846 tons were under construction, of which 22·34 per cent were being built in Great Britain and Northern Ireland. Of the total, 339 ships of 5,497,170 tons, or 55 per cent, were oil tankers, while the tonnage for export totalled 4,081,511 tons. Tonnage building under the inspection of Lloyd's Register amounted to 5,612,836 tons, or 56·1 per cent of the world total.

Wage Increase

The 250,000 workers employed in the civil engineering contracting industry in Great Britain are to receive a wage increase of 1d. an hour as from Monday, February 2. This increase has been agreed by the Civil Engineering Construction Conciliation Board in accordance with the industry's sliding scale agreement based on the index of retail prices. With the increase, the basic hourly rates of pay become 4s. 9d. and 4s. 10½d. for craftsmen and 4s. 2½d. and 4s. 4d. for labourers.

Large Plano-Milling Machine

A plano-milling machine recently designed and built by Schiess A.G. is capable of machining the sides, tops and ends of workpieces weighing up to 150 tonnes. The machine, which weighs about 900 tonnes, admits work up to 4·5m square on its 20m long table. It is designed for precision push-button setting with reference to optical equipment, and all movements can be controlled from two push-button desks mounted on adjustable platforms at the sides of the machine.

FOR many years the firm of Schiess A.G., Dusseldorf, Germany, has specialised in the manufacture of very large capacity machine tools as well as its well-known range of medium and heavy boring and other machines. We recently had an opportunity to see, undergoing tests at this company's works, what is believed to be one of the largest plano-milling machines to be built in Europe. This machine weighs some 900 tonnes and it has been made to meet the special requirements of Sulzer, Ltd., of Switzerland. It is designed to machine parts weighing up to 150 tonnes. Such parts can be up to 4·5m square and the two tables of the machine can be coupled together to provide a working surface with an overall length of 20m. The general layout of the machine can be seen in the photograph below, which was taken during assembly at the Schiess works; the dimensions given on the end elevation drawing we reproduce give a further impression of its massive construction.

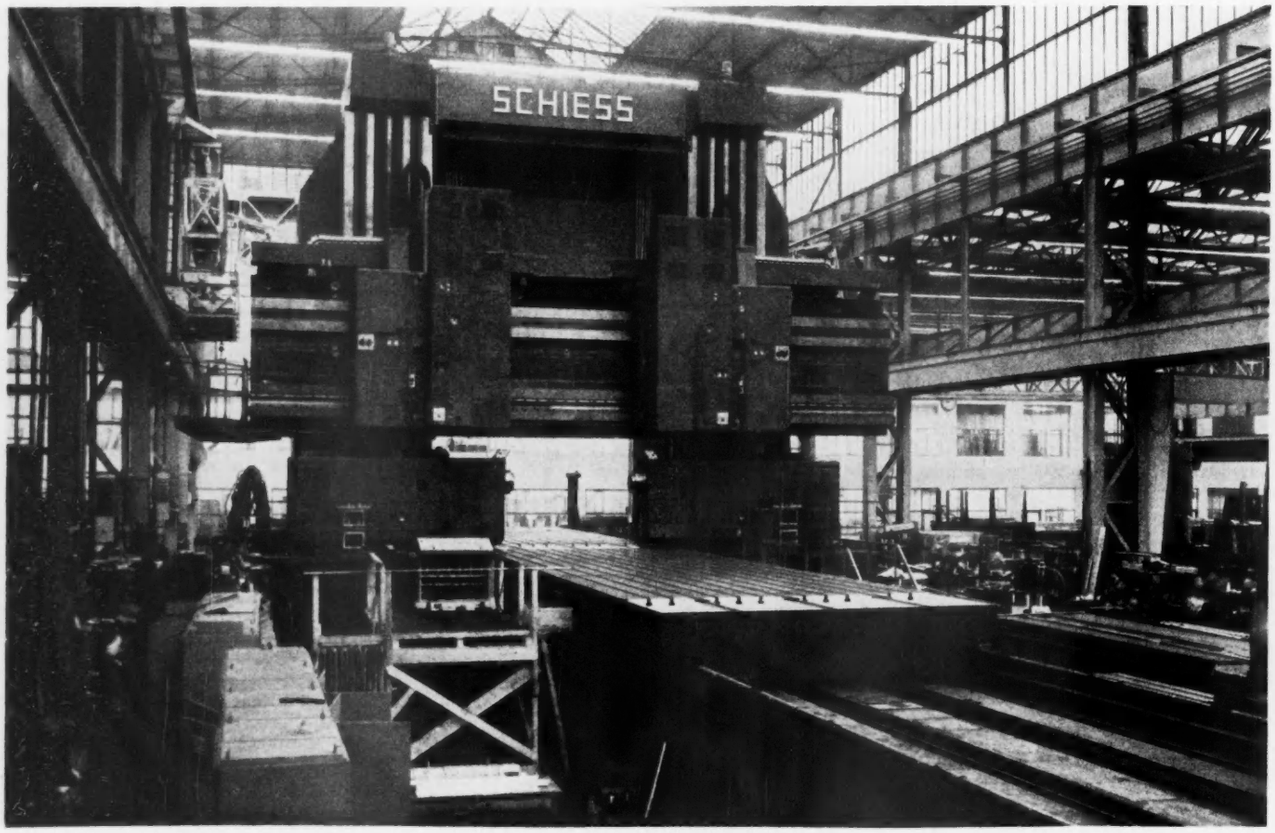
The 46m long bed of the machine, with an overall width of 3·55m, weighs some 320 tons and consists of five cast sections. The degree of accuracy which had to be observed in the machining and assembly of this bed will be appreciated when it is pointed out that the stipulated tolerance which had to be observed was that the deviation over the full length should not exceed 0·06mm, or 0·02mm over any 1m of length. Across the width of the ways the stipulated tolerance was 0·01mm per 1m. In order to check the bed accuracy normal optical or other measuring methods could not be used, and the makers adopted a very old, but simple and effective, system in which water is used. For this purpose there has been laid round the top of the whole bed a pipe of about 10cm diameter with sections, about 30cm long, cut out of its upper part, spaced 1m apart. When water was poured into this pipe it provided a trough in which the water level could be checked at each of the open sections. For this purpose a precision level bar was fitted with an electrical contact device, and when the bus was placed across the bed ways the contact element could be lowered a measured distance until it touched the surface of the water. This form of checking the bed level against the constant water level by instantaneous electrical registration of contact proved completely successful in aligning the bed to the required tolerances.

The two tables, which have working surfaces 8·5m and 11·5m long respectively, can be used individually or coupled together to provide a single table 23m long over the end chip trays. The length of the bed is such that either table can be parked at the end of the machine and loaded with a workpiece whilst the other table is in operation. The tables are driven through two sets of racks and pinions by a Ward-Leonard equipment with two 150 h.p. motors. These motors can be used singly when individual or lightly loaded tables are in operation, or their output coupled through a gearbox for driving at maximum power. A 5 h.p. motor drive is provided for inching the tables when setting work. Three ranges of table speeds are provided through electromagnetic clutches in the transmission gearbox to give a stepless range of speeds from 1·5mm to 10,000mm per minute.

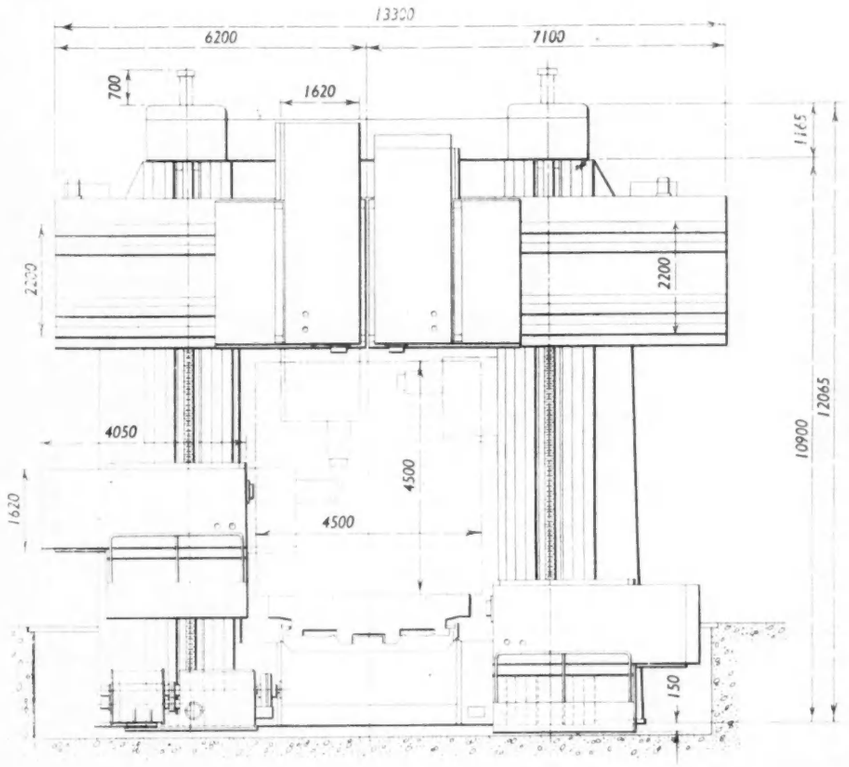
The size of the tables and the very heavy workpieces which have to be machined make adequate lubrication of the ways of particular importance. For this purpose a high-pressure oil system is connected to a series of points along the ways, and as the table travels along valves at each of the lubrication points are opened to admit a supply of oil, which is shut off immediately the table has passed. The pressure in the lubrication system is adjustable in accordance with the weight of the work being machined on the tables. Excess oil collected at the bottom of the ways flows back to a tank, whence it passes through filters before recirculation.

When the machine was being designed it was concluded that the expense of machining and the difficulties which would have been involved in providing satisfactory castings for the main columns would be excessive, as such columns would require complicated castings weighing 130 tons at least. It was, therefore, decided to use, for the first time on such a large machine, columns of welded plate construction. Before actual fabrication of the columns was started a true-to-scale model of transparent plastic sections was built up in order to determined the most suitable welding sequence which could be followed on such a complicated structure. When completed each of the columns weighed some 100 tonnes. To provide the length of material for the two sets of guide ways on each column seven batches of a special steel were cast by a special process, and the four best sets selected for use. These ways were machined and heat-treated to impart a 170 to 180 Brinell hardness. They have the general form of a "T" and the foot of the "T" is welded into the main structure. This shape was selected in order that the heat generated in the welding process should not adversely affect the hardness of the main way surfaces.

The columns are coupled to the bed and the main bridge beam through precision machined



900 tonnes plano-milling machine being erected at the maker's works. For testing purposes one of the control desks has been set on a platform at the foot of the left hand column



End elevation of plano milling machine, showing major dimensions and range of spindle head saddle adjustments

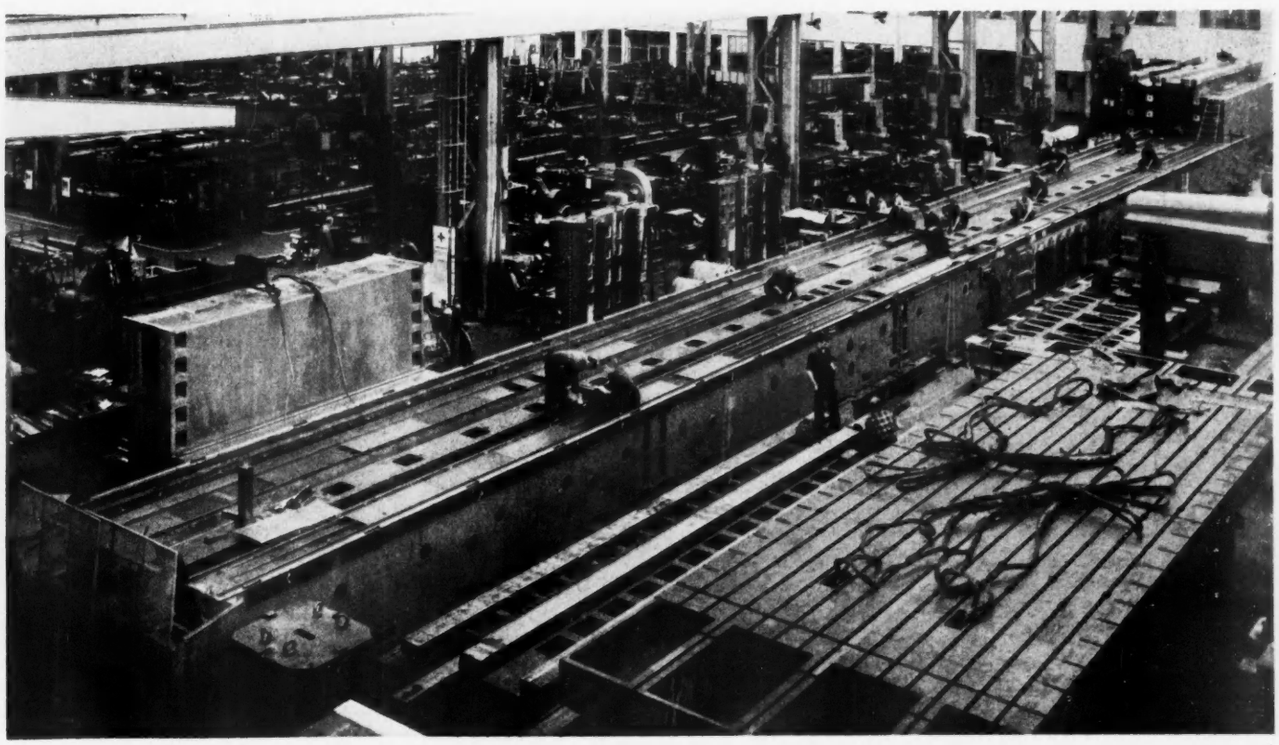
faces, and the assembly is rigidly held by high-tensile bolts on which the nuts are tightened, using tension wrenches. In final assembly, the deviation of the column slides from the vertical had to be maintained within 0·03mm overall.

The main cross rail, weighing some 70 tonnes, which is carried on the column ways, has a width of 13·3m and an overall height of 2·8m. This rail is supported through replaceable phosphor-bronze wear plates on the column slides, and each time it is unclamped for movement oil is automatically supplied to the ways from a high-pressure lubrication system. Vertical adjustments of the rail are effected through large diameter screws and bronze nuts driven by two 50 h.p. d.c. motors with Ward-Leonard control. These two motors are synchronised and give vertical feed rates of between 15mm and 310mm per minute. Settings of the rail on the columns are effected with optical measuring equipment, and if the rail deviation on the columns exceeds a predetermined limit, all movements are automatically locked to prevent further movement until the deviation is rectified. In order to provide a check on the bronze nuts which are subjected to most wear, an interlock stops the machine if the wear exceeds 2mm or the difference in wear of the two nuts exceeds 0·5mm. It should be pointed out that one of the reasons for maintaining a high degree of accuracy on the column and cross rail members is that when a special angle milling fixture is fitted to one of the heads the vertical feed of the cross rail is used for milling the ends of components on the table.

The counterbalancing system for the cross rail is combined with that of the side milling heads on each column. Through a pulley system and weights, which move in guides within the columns and down into their foundations, the full weight of each side head and 80 per cent of that of the cross rail are counterbalanced.

Two workheads carrying milling spindles are mounted on saddle assemblies on the cross rail, one of the saddle slides having a vertical travel of 1000mm and the other 1500mm. Similar workheads with a horizontal slide traverse of 1000mm are mounted at the side on each column. Each head assembly is complete with its own spindle and feed drives, and all feed movements are effected by d.c. motors with Ward-Leonard control.

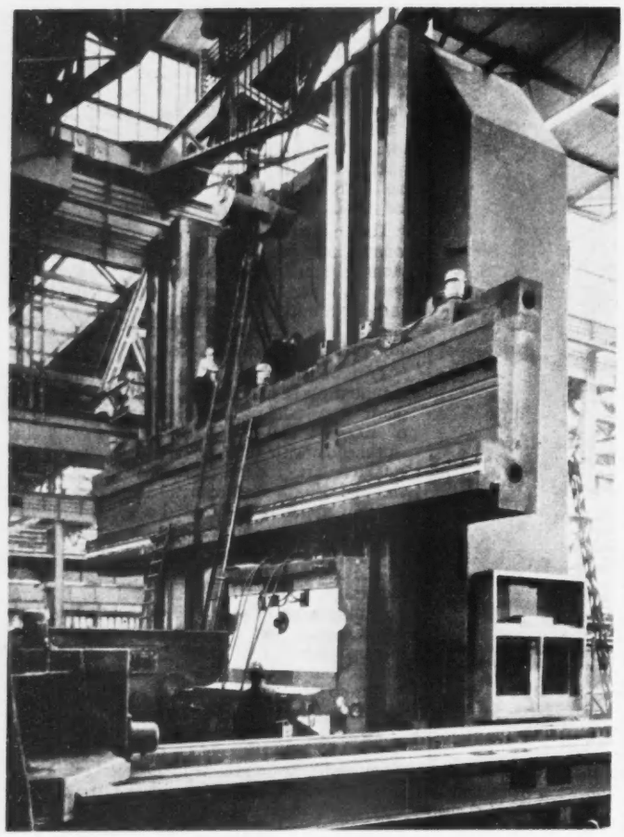
The saddle feed rates along the cross rail are steplessly variable between 5mm and 1600mm per minute. The sliding feed drive of the cross rail saddles is transmitted via a gear mechanism through a combination of a screw and nut and a rack and pinion. This transmission mechanism is so designed that a majority of the driving torque is applied through the rack and pinion gear, and the remainder through the nut and screw. This arrangement is designed to ensure a long and consistently accurate working life for the precision screw, and the importance of reducing the load on the screw will be appreciated when it is pointed out that one of the head assemblies weighs 26 tonnes and the other 24 tonnes. When it is required to mill the end



Main bed sections being assembled with levelling water pipe in position round the upper periphery. One of the two tables can be seen in the right foreground, and the right-hand column is lying on the floor at the far end of the bed

faces on a workpiece a special angle milling attachment can be fitted on one of the vertical heads.

The horizontal spindle saddles on the side columns are moved through worm and worm rack located in the columns. These heads have feed rates between 5mm and 1600mm per minute, and, as already mentioned, the whole of their weights are counterbalanced through the cross rail system.



Cross rail being fitted on the column slide ways

All of the spindle head saddles are automatically clamped to their guide ways by cam-operated lever mechanisms between setting operations and when their feed is not engaged. They are fitted with renewable phosphor bronze wearing plates and their slides are automatically lubricated whilst the heads are in motion.

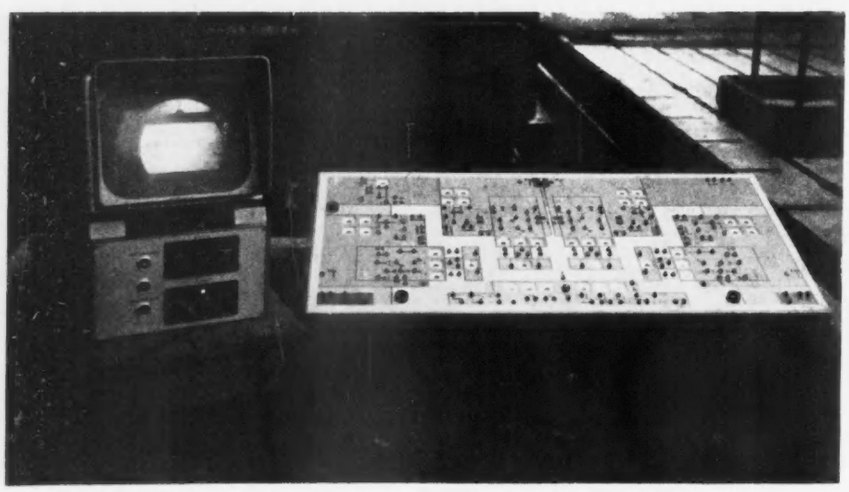
The quill-mounted 320mm diameter milling spindles are carried on selected high precision bearings and are designed to be within a maximum eccentricity of 0·01mm. It was further stipulated that the run-out of their front flanges should not exceed 6 microns after assembly. Each of the milling spindles is driven by a 100 h.p. motor in its head assembly, and has three stepless ranges of speeds—4 to 60 r.p.m., 12 to 190 r.p.m. and 25 to 400 r.p.m. Gear changing is effected electro-hydraulically through clutches and with a push button control. In the two lower speed ranges the drive is transmitted to the spindles through gearing, but in the high speed range power is transmitted directly through a special flat endless belt. Each spindle, through the quill mounting, has a feed movement over a length of 700mm at rates up to 250mm per minute.

A point of particular interest in the design of each of the spindle heads is a means which is provided for a slight tilting adjustment which can be made to incline the milling cutter to impart a small relief angle during machining. With the adjustment provided a milling cutter can be inclined in any of four directions up to about 0·1mm per metre of its diameter. This adjustment is effected by four pads spaced round the front end of the quill assembly and a tapered nose ring. When it is required to tilt the spindle this nose ring is screwed down a pre-determined distance in accordance with the required angle. A balanced hydraulic jack system behind the pads is then supplied with pressure fluid and taper wedges at the back of the pads are moved. As one of the wedges on one side is withdrawn that on the opposite side is pushed in to move the quill end over the amount permitted by the tapered nose ring. The length of the quill assembly is such and the degree of adjustment made at the front end so small that the off-set does not affect the accuracy or running of the bearing mounting at the top of the quill.

There is also included in each quill assembly a mechanism which withdraws the milling cutter about 2mm at the completion of each cut to clear the tool from the work during its return movement. At the end of the return stroke the cutter is reset for the next operation to pass within 0·01mm of its original position.

All settings on the machine are effected through push-button controls, with reference to optical instrumentation, to a tolerance of 0·01mm. In addition to individual stations or platforms by each side head, the cross rail and the foot of the columns, there are provided two main control desks on platforms supported from separate column structures on each side of the machine. On these columns the platforms can be raised, lowered and swung to any convenient place for the operator to have a clear view of the work. The control buttons on the two desks are interlocked so that movements and adjustments can be made from either station. These desks were designed and supplied by Brown-Boveri, Ltd.

One of the main control desks is shown in one of our illustrations where it will be seen that the push-buttons are arranged on a diagrammatic plan of the heads and table. In addition to the directional control buttons the panel includes speed and feed setting and indicating equipment for all motions. It is planned at some future date to provide on the control platforms television screens coupled to the eleven principal optical setting equipments on the machine. Through a selector switch on the television unit the readings of any of the optical equipments can be projected, as shown in our illustration. The vernier setting is projected on the top arc on the screen and the main metre setting below, and with reference to them the necessary adjustments can be made through the inching control buttons on the desk. With this television equipment in use, control is concentrated on the two platforms, to considerably facilitate and speed all operations and settings on this very large machine.



Push-button control desk, with television screen on the left showing one of the optical slide setting units

Paris-Lille Electrification Opened

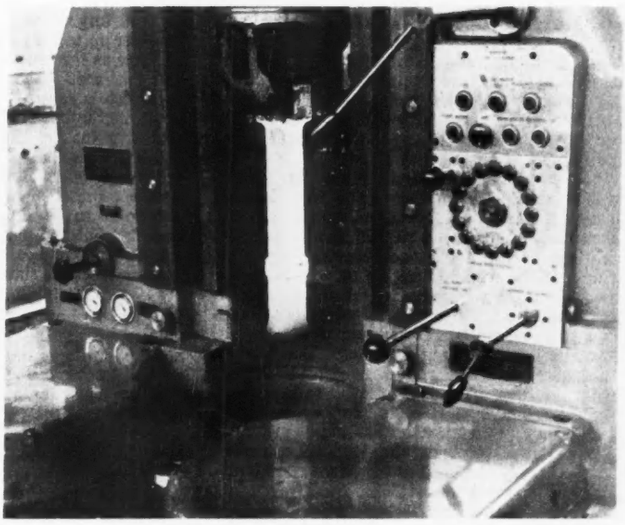
Electric traction was introduced on train services between Paris and Lille on January 11, after an official inauguration had taken place on January 7. Completion of this industrial frequency electrification, and the new locomotives which are operating the services, have been referred to already (THE ENGINEER, January 9). The whole scheme covers 388km (241 miles), since in addition to the Paris–Lille main line itself it has extensions, in hand or completed, to the principal mining and industrial centres around Lille, such as Lapugnoy, Béthune, Lens, Somain, Azincourt and Valenciennes. In the Paris area the electrification is being extended to serve the marshalling yards at Le Bourget and the express goods traffic depot at Noisy-le-Sec. All this work forms the second stage in an electrification programme covering the triangle of main lines between Paris, Lille and Strasbourg. The first "side" of the triangle, from Lille to Strasbourg, was electrified in stages between 1954 and 1956, and later extended to Basle. Work is in progress on electrifying the third side, from Paris to Strasbourg.

Civil engineering work to improve the capacity of the Paris–Lille line includes a new flyover at Creil which allows trains from the Lille direction to by-pass the junction at Nogent with the line to Tergnier and to run into Creil station at the same time as a train from the direction of Tergnier and Aulnoye. Electrification of this route from Creil to the Belgian frontier figures in the current S.N.C.F. electrification plans and would be accompanied by conversion of the line from Verberie to Paris so that freight traffic from Belgium and the Valenciennes–Aulnoye area could by-pass the busiest section of the Paris–Lille main line between Creil and Paris.

Since January 11 the fastest trains between Paris and Lille have been retimed to make the journey in 2 h 15 min, and other expresses in 2 h 40 min, these being accelerations of from 10 to 20 min on previous timings. Further accelerations to 2 h 10 min and 2 h 35 min will take place in June this year.

Rotary Precision Forging Plant at Buffalo

BY OUR AMERICAN EDITOR



An unusual precision rotary forging machine was recently installed by the Metals Processing Division of the Curtiss-Wright Corporation at Buffalo, New York. The rotary forging method of producing shafts and shaft-like parts is capable of distributing metal during the hot or cold forging process to match precisely a predetermined contour. The plant can handle both solid and hollow forgings and employs three or four synchronised forging hammers operating at up to 600 blows per minute.

THE first American installation of a "GFM" rotary precision forging plant recently went into operation at the Metals Processing Division of the Curtiss-Wright Corporation, Buffalo, New York. The rotary forging method of producing shafts and shaft-like parts has some important characteristics that distinguish it from other methods. The key to the difference is in the ability of rotary forging to distribute the metal to match precisely a predetermined contour. Previously, the forming processes used could only roughly approximate the desired contour and required considerable amounts of machining and boring to meet finish tolerances. Most parts so made, by a sequence of separate operations, can now be finished to blue-print in a single rotary forging operation.

Rotary precision forging is neither drop forging nor upsetting, rolling, extrusion or swaging. It is a high-speed, highly precise method for producing pieces of varied symmetrical cross sections from simple starting blanks. Precision forging machines can forge hot or cold, round or square, solid or hollow billets. Outside surfaces are formed smoothly and precisely over a variety of contours with simple, inexpensive hammers, which in many cases are interchangeable from one piece to another. Where hollow or tubular pieces are involved, the inside contours may be developed and held to close limits by the use of mandrels. The workpiece is chuck fed. The forging operation is almost entirely automatic, governed by preset hydraulic controls, very similar to those of a turret lathe. The new mahine can forge workpieces which heretofore had to be turned, drilled, bored, broached or otherwise shaped by metal removal.

During World War II, German production engineers experimented with forging the lands and grooves into drilled gun barrel blanks. By cold forging the rifling over mandrels they got a much better barrel and saved critical time, materials and broaching tools. However, conventional equipment used for this purpose had serious drawbacks. Impact forging machines with rebounding hammer elements could not achieve highly accurate outside dimensions unless working die-to-die. Mechanical presses and rotary swaging machines did give positive metal displacement. However, because their working forces are always delivered in a fixed line between rigid parallel guides, such machines require intermediate ball or knuckle joints between the actuating mechanism and the forging member. None of these machines provided means for a continuous or phased adjustment of tool travel to effect a predetermined varied dimensioning of the workpiece cross section in a single, uninterrupted, automatic operation. Toward the end of the war a new gun barrel forging machine design began to take shape in the minds of a few German engineers. After the war a prototype machine was developed and the first production machine has now been installed in the United States of America.

Machine Design

As shown in Fig. 1, the forging members converge radially on the workpiece somewhat as they do in a rotary swaging machine. However, there is a significant difference. Each radial forging member is, in effect, a solid connecting-rod driven by an eccentric. There is no intermediate knuckle or ball joint of any kind. None is necessary because all radially positioned members are commonly guided by a floating guide ring which moves freely with the synchronous oscillations of the forging members. Each driving eccentric is itself eccentrically mounted in a separate adjustment housing in the base of the machine. Therefore, by turning all eccentric adjustment housings simultaneously, it is possible to move the working perimeter of the forging members inward or outward in relation to the central axis of the workpiece.

These two features make possible the consistently high precision and the ready adjustability which characterise the process. Other unusual design ideas in these machines are largely predicated on these two basic patented features. The operation of the original gun barrel forging machine was improved and extended. Automatic feeding and indexing controls were added, together with other refinements. One of the original machines is still being used for cold forging rifle and other small gun barrels, and for cold finishing other relatively small precise shapes. Out of this grew the unit installed in America which is illustrated above, and is equipped with a mandrel mechanism for use in controlling inside diameters when forging some hollow shapes. These vertical machines have three or four forging hammers striking synchronously at 540 to 600 blows per minute. Each hammer develops a forging force of 110 to 132 tons. The machines are built to take stock diameters up to 5in and forged lengths up to 48in.

Larger forgings require greater forging forces and larger forging mechanisms. The size of such forging machine components and the size of the work itself usually make vertical forging unwieldy and impractical. Machines in such larger capacities are now being built to handle the work horizontally. These machines will accommodate work diameters up to 12in and will finish forge lengths up to 78in. Each of four hammers delivers a potential forging force up to 220 tons.

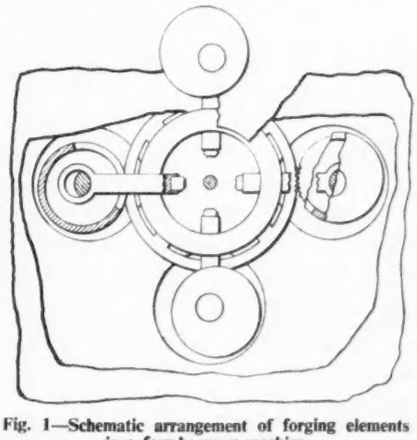


Fig. 1—Schematic arrangement of forging elements in a four-hammer machine

Operating Principle

The schematic layout in Fig. 2 is for a three-hammer vertical machine, which may be considered typical. The heart of this forging machine is the forging case. Here are located the forging hammer assemblies. Three of them are shown in Fig. 2, but there are often four, and there may be more, depending on the work for which the machine is designed. Each hammer assembly

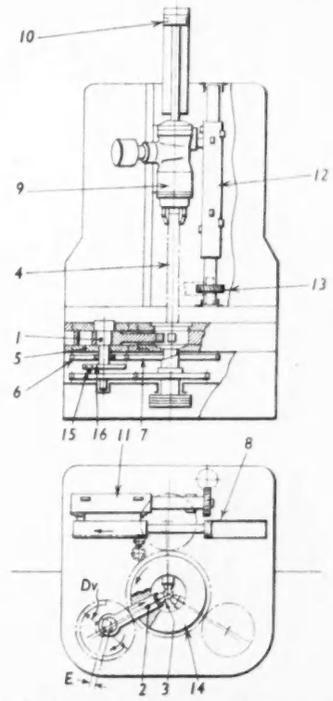


Fig. 2—Schematic arrangement of representative three-hammer vertical forging machine

consists of a rapidly revolving eccentric shaft 1, which transmits its force directly to the work through a straight connecting-rod 2, on the end of which is fastened a hammer 3. No matter how many hammers are used, their axes are an equal distance from each other on a circle inscribed about the axis of the workpiece. These hammer assemblies operate synchronously

Therefore, the piece is struck on all sides simultaneously. Thus, a workpiece of any symmetrical cross section, when rotated among these hammers, is forged to a diameter described by the hammer faces at their maximum inward points of travel. If the piece is not rotated it is forged to the shape of the hammer faces on as many sides as there are hammers.

Between the eccentric shaft and the forging case is an adjustment housing 5. This housing is itself mounted eccentrically in the forging case. Therefore, since the eccentric shaft has fixed bearings in the adjustment housing, the pivot points of the eccentric can be moved toward or away from the workpiece by turning the adjustment housing. By turning all adjustment housings an equal amount at the same time, a change is made in the forging diameter. This is done through gears 6 which are flanged on all adjustment housings and are all meshed to a common central sun gear 7, which is actuated through a rack and pinion by a hydraulic piston 8. Movement of the hydraulic piston is controlled by preset, adjustable stops or templates mounted on an index drum 11. In this way cross-sectional forging dimensions can be automatically controlled according to precalculated settings.

The chucking head 9 holds the piece and usually rotates it, as it is fed through the forging case. A hydraulic piston 10 moves the chucking head up and down in its guides ; the amount of this vertical movement is controlled by another system of adjustable stops set on a second index drum 12. Control of the workpiece cross section is co-ordinated with control of sectional length. This is done by relating the settings on the index drums. The index drum 11 which controls hammer location and the index drum 12 which controls chuck movement are synchronised through worm gears 13. As soon as a preset length of a preset diameter is completed, a hydraulic indexing device turns both index drums into the next position where another set of preset stops or templates control hammer position and chuck movement.

Forging Cycles

The forging cycle for most workpieces is fully automatic after the operator chucks the piece and pushes the starting device. This can be seen by following the action of the machine on two simple working diagrams reproduced in Fig. 3.

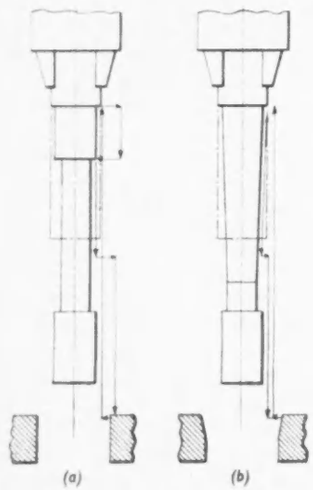


Fig. 3—Diagram of representative automatic forging cycles

These diagrams visualise the hammers being moved continuously along the workpieces ; actually the hammers remain in a fixed plane while the workpiece is rotated and fed up and down between them. Example (*a*) is of a very simple automatic forging cycle. Corresponding sectional workpiece lengths and diameters are fixed and controlled by co-ordinated settings of stops on the index drums. The starting stock is a cylindrical billet shown by the dotted lines. The already moving hammers first close to preset working positions coinciding with the largest required forged diameter. The entire length of the billet up to the top shoulder is forged to this diameter as the billet is rotated downward. The hammers then open and the direction of the workpiece is reversed. It is rotated upward to the preset lower limit of the second shoulder. At this point the hammers close automatically to the smallest diameter and reduce the piece to this dimension until the bottoms of the hammers reach the preset length for this section. Stops at this point cause the hammers to open again while the finished piece is carried upward to the top, or chucking position. In this example the hammer faces are simple cylindrical sections.

Example (*b*) is similar except that it illustrates the use of both indexing stop and template follower control. The workpiece is lowered rapidly through the open hammers to the bottom of the top shoulder. At this point the hammers close automatically, forging the radius at the top of the taper. Then, as the piece is rotated upward, the hammers are progressively closed as they forge. This action is regulated by a taper template on the indexing drum which controls the working position of the hammers. When the bottoms of the hammers reach the preset length of this section they complete the reduction of the piece. It is then carried rapidly up to the chucking position and removed as before. In this example the top halves of the hammer faces are conical sections, and the bottom halves are cylindrical sections. In practice, it is interesting to note, either of these axles can be forged in a total time of thirty seconds or less.

The practical use of the adjustment system just described for length and diameter control requires further design considerations in the machine. The most important of these is that none of the forging forces may affect the system. Were this not the case, the system would need to be so heavily constructed to support such forces that it would be of no practical use. To avoid a reaction of the forging forces on the adjusting system of the precision forging machine, the diameter *Dv* of the adjustment housing 5 is designed to have a specific relationship to the eccentricity *E* of the bearings of the eccentric shaft. As can be shown mathematically, at a particular ratio between *Dv* and *E*, the moments of friction of the applied forging force hold the adjustment housing firmly and prevent its movement in the forging case. Because of this design it is possible to control great forging forces securely and to obtain adjustment with only limited hydraulic pressures.

As has been noted, hammer location adjustments can be made throughout the forging cycle. However, hammer adjustment takes place only during the intervals when the hammers are not in contact with the workpiece. At these times no forging forces are being applied, and there is no reaction on the hydraulic adjustment system. During the application of forging forces, hammer location adjustment is halted, and the hydraulic fluid effecting this adjustment passes through a relief valve.

It has been pointed out that these machines develop forging forces up to 220 tons per hammer and speeds up to 600 strokes per minute. Such forces and speeds also require special considerations. The schematic arrangement shows the basic design which makes these forces and speeds possible. The forging hammers are fastened directly to the connecting-rod. No intermediate knuckle or ball joint is necessary between the driving eccentrics and the hammers. No separate ram is used. All connecting-rod guides are located in a common housing 14, which swings freely back and forth around the central vertical axis of the forging case. Therefore, these guides constantly parallel the connecting-rods during radial oscillations caused by the rotation of the eccentric shafts. Because the guide housing follows the movement of the connecting-rods during each stroke, the connecting-rods are snugly guided and the hammers precisely directed toward the central axis of the forging case, which is also the longitudinal axis of the workpiece. The high forging pressures are taken up entirely on the bearing surfaces of the eccentric shafts. This limits the areas in which wear can take place and contributes considerably to accuracy and reliability.

Driving Mechanism

The bottom of each eccentric shaft is securely fastened to a flywheel 16. Each flywheel in turn engages with a corresponding gear in the mechanical transmission. Engagement is made through a drive block 15 on the adjacent periphery of each gear riding in a slot in the flywheel. This type of driving connection permits changing the position of the eccentric shaft axis and thus the position of the flywheel while the gear remains in the same position. This arrangement for engagement between driving gear transmission and the forging mechanism is, therefore, also a factor in the free, automatic control and adjustment of forging dimensions.

The gear transmission and the forging mechanism are situated in a gear case and forging case, respectively. Both cases are made of heavy welded steel plate. It should be noted that these two cases are the bottom, supporting sections of the machine. They are substantial members, ruggedly constructed, but they lack the massive proportions usually associated with heavy forging equipment because none of the forging forces set up are transmitted to the supporting structure of the machine or to its foundation. Since the forging hammers strike the workpiece from all sides simultaneously, the forging forces are equally distributed and entirely self-contained. For this reason, there are no unusual considerations in selecting the location and designing the foundation for these forging machines. They can be treated very much like other machine tools.

The chucking head is normally rotated at constant speed. It may also move upward or downward through any portion of the forging cycle at a constant preset speed. It is necessary to compensate for the momentary arresting action of the hammers on the workpiece each time a blow is struck. For this reason, the chucking head spindle is axially cushioned by a rubber shock absorber and a torsion spring is provided in the rotation drive unit.

In following hollow work, for which inside contours and dimensions are critical, a mandrel is used. This mandrel is fastened on the end of a mandrel rod which passes through the chucking head spindle. The mandrel is inserted or retracted by moving the piston in the separate mandrel actuating cylinder. This movement may be regulated by a manual mandrel control valve. A hydraulic lower guide is sometimes employed on the machine. This is used when the upper end of the blank cannot be held in the chuck. In such operations the workpiece is placed on the lower guide and the chucking head presses down against it. Then, with or without the mandrel inserted in the usual way, the chuck forces the workpiece through the forging case against the opposed but lesser hydraulic pressure of the lower guide. Otherwise forging operations with a lower guide are the same as others.

Set-Up Practice

Setting up for a job is comparable to setting up a turret lathe or an automatic screw machine. Set-up plans can be made in advance. By using direct reading scales on the machine the set-up man can place the length and diameter stops on the index drums. Settings can be approximately related between vertical and horizontal drums in accordance with the prescribed sequence of automatic forging operations. Templates for rounded or tapered sections can likewise be positioned on the taper template drum. Thus, feeding speed for each operation can also be precalculated and set. Some slight adjustment may be necessary after a trial forging has been run and checked for dimensions and surface. However, none of this need depend on the skill or judgment of the operator. When final adjustments have been made, the machine automatically reproduces forgings of identical proportions and surface quality until the hammers or the mandrel become worn.

The forging hammers are made of a high-strength alloy tool steel. They are usually simple in shape and inexpensive to make. Their working surfaces are armoured with Stellite. Worn hammers can be reused after regrinding, or after applying another coat of Stellite and then regrinding. The tool costs are, therefore, very

low. The mandrels are made of high-strength, hot working alloy steels and usually are oil hardened. Mandrels for large diameters may be hollow and they are sometimes water cooled.

The precision of these machines is a principal aspect of their significance. When forging hot, outside diameter tolerances can be held within plus or minus 0·012in ; inside diameters within plus or minus 0·004in. Cold forging may be held still more accurately—plus or minus 0·004in outside and 0·0004in inside. Such tolerances combine with a surface finish which is frequently suitable for use without further machining. The precision and surface quality of hot work obviously depend to some degree on controlled and uniform heating. The precision of all work depends on the accuracy of the tools.

Temperature Control and Lubrication

To maintain continuous production from shift to shift, the heat transmitted to the machine from the workpiece must be carried off. For this reason the bearings of the connecting-rod guide housing and of the flywheels are water cooled within the forging case, and the forging case is further cooled by blowing compressed air through it. The bearings of the eccentric shafts in the adjustment housings and in the connecting-rods receive the full impact of the forging forces. These bearings are of white metal, lubricated by oil which passes under pressure through the hollow centre of the eccentric shaft. Pressurised oil also seals and lubricates the bearings between the connecting-rods and guide housing. The oil running out of these bearings flows down into the transmission, where it furnishes further lubrication and then returns from the gear case through a drain pipe to the oil reservoir.

A water cooled hollow shaft passes down from the forging case through the transmission case. This arrangement protects the transmission from the heat radiated by the working piece during hot forging, and allows scale and dirt to fall freely into a special container in the foundation pit. The oil for the hydraulic system and the oil for the lubricating system are pumped to and through the forging machine by an auxiliary oil pump mounted on the oil reservoir, next to the machine. A special filter is usually installed in the oil drain to clean the oil continuously during operation. To remove the mandrel from the workpiece in case of sticking, there is an additional oil pump on the machine. This is a small, high-pressure unit with low delivery, giving about 1100 lb per square inch gauge. The operator needs only to press an electric button to get an upward jolt of over 11 tons on a sticking mandrel.

Precision Forging Work

It is not practical to list all of the various items and parts for which this method of forging is now used and for which it is being considered. It is, however, useful to consider typical classes of work so that some indication may be obtained of the practical working scope of the process. One of the simplest and most effective applications is in the reduction and sizing of solid shafts. This may take the form of mere contoured end reduction as is done with trailer axle shafts, worm gear shafts, or of a series of stepped cylindrical reductions extending over the entire area of the workpiece as in the case of electric motor shafts and conventional automotive axles. It may involve reproductions of moderate curvatures or tapers over given sections of a length as is required on the bodies of some axle shafts or a shotgun barrel blank. Or the work may not involve shaping at all. It may be merely a reducing or sizing operation involving particular diameters and/or tolerances. Precision forging machines can be used for this purpose to produce limited quantities of billets in particular sizes where requirements are not sufficient to justify rolling.

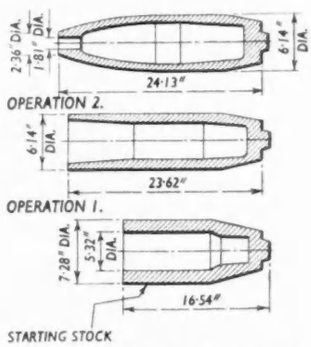
Still another application is in the reduction of tubular shafts. In some cases this involves changes merely in outside dimensions which very closely parallel work described before involving solid shafting. In many cases, however, precise control over the internal contours and dimensions of the tubular piece is required. Also, highly precise control over concentricity and wall thickness may be necessary. In these instances, a wide variety of mandrel shapes and positioning arrangements can be employed with highly effective and accurate results. The simplest mandrel is a smooth one used principally for sizing or controlling wall thickness. Somewhat more complex are the mandrels used for creating various internal shoulders, tapers, and curvatures. In a somewhat different category are mandrels designed to reproduce internal splines, gear teeth, and other axial internal deviations. It should not be overlooked that the process was originally developed to perform one of the most difficult and precise operations that can be undertaken with a mandrel, i.e., the rifling of gun barrels. These and many other items are forged from lengths of tubing or other hollow blank shafts, with some elongation, but principally by reduction.

A third and possibly most significant basic category involves the development of tubular shapes and sections principally by elongation. In such cases the objective is to select the least expensive starting blank which can efficiently be precision forged to the desired finished shape. Shells, for example, are precision forged as illustrated in Fig. 4, either from pierced cups (*a*) or from simple dished drop forgings (*b*). In the one case the blank is press-pierced from a cylindric slug. In the other case it is hammered or pressed from a flat pancake or disc. Pipe couplings of large and intermediate size can be produced from standard mill-run tubing, as indicated in Fig. 5. This eliminated the necessity of producing less profitable coupling stock on merchant tube mills. For oil field tool joints a variety of starting blanks have been considered. The most economical possibility now appears to be trepanned cylindric slugs, as shown in Fig. 6. The economic desirability of this course is further enhanced if a worthwhile use or market can be found for the cores. A compressor rotor shaft for an aircraft gas turbine affords still another good example of the variety in starting blanks which can be selected. Such rotor shafts have been variously forged from short lengths of heavy-walled pipe, from flanged stampings, and from simple drop forged rings. In each of these cases the process is used in such a way as to minimise starting material stock costs.

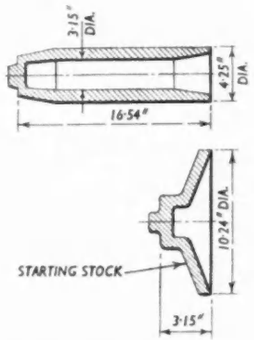
This discussion of the basic precision forging work categories gives some indication of the flexibility inherent in this process. This flexibility is further enhanced by two additional considerations, applicable in varying degrees to all precision forging machines : tooling is relatively very inexpensive and set-up time from one job to another is relatively very short. Precision forging machines can be designed and built to mass produce only one or a very few shapes in a highly "automated" set-up which remains essentially unchanged from one month to the next. Standard models, however, lend themselves readily to short runs as small as a few dozen pieces. A set of four simple hammers for a small vertical machine may cost as little as 200 dollars. The working surfaces of these hammers are armoured with Stellite and are good for from 1500 to 15,000 pieces between changes, depending on the nature and precision of the job. All four can be removed and replaced in about half an hour. Worn hammers are salvable by the addition of Stellite and regrinding to the original contours.

Where precision forging work is done hot, uniform heating is necessary in order to achieve straightness and concentricity in the finished pieces. Very fast heating and heating in controlled atmospheres are no more essential than they are for any other forging process. Hollow pieces which are to be hot worked over a mandrel will naturally benefit from scale-free heating because the scale on the inside of the blank tends to be entrapped and embedded when forged over a mandrel in this way. However, scale on the outside of a blank is of less concern than it is in almost any other type of forging operation. Because the forging hammers bite into the piece in relatively small over-lapping increments as it is fed and rotated through them, they serve as effective scale breakers. The outside of any hot worked precision forging is, therefore, almost completely free of loose or embedded scale. It is also interesting to note that stock heats for precision forging rarely exceed 1800 deg. to 1850 deg. Fah. since the exceedingly rapid action of the hammers tends to conserve and generate heat in the stock.

Pressure Pickups.—An existing agreement between the Consolidated Electrodynamic Corporation, Pasadena, California, U.S.A., and the Solartron Electronic Group, Ltd., Thames Ditton, Surrey, has been extended to include a range of C.E.C. pressure pickups developed primarily for the aircraft industry. The pickups, which are temperature compensated from −350 deg. to +650 deg. Fah., are designed for the precise measurement of rapidly changing pressures and operate as transducers for feeding electrical signals into data processing equipment. They are stated to have applications in nuclear work, their construction making them capable of operating under conditions of medium intensity gamma radiation for long periods without loss of performance.

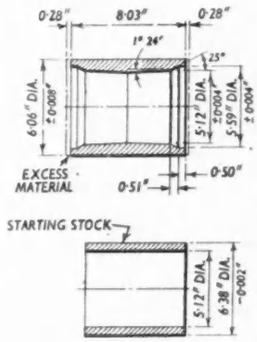


Forging time 20 seconds. Handling time 40 seconds. Floor-to-floor time 60 seconds. Production per hour fifty pieces Operation 1. Forging time 25 seconds. Handling time 25 seconds. Floor-to-floor time 50 seconds. Production per hour sixty pieces. Operation 2.

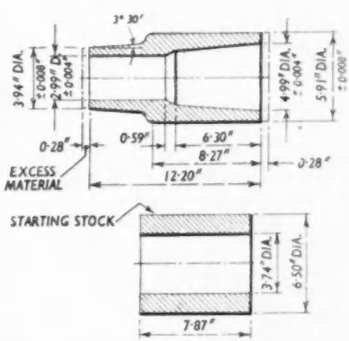


Forging time 25 seconds. Handling time 25 seconds. Floor-to-floor time 50 seconds. Production per hour sixty pieces.

Fig. 4—155mm shell developed by precision forging from pierced blank (left) and from drop forged blank (right)



Forging time 17 seconds. Handling time 20 seconds. Floor-to-floor time 37 seconds. Production per hour eighty pieces.



Forging time 17 seconds. Handling time 20 seconds. Floor-to-floor time 37 seconds. Production per hour eighty pieces.

Fig. 5—Pipe coupling precision forged from tubing stock

Fig. 6—Pin end of oilfield tool joint precision forged from tubular blank

Personal and Business

Appointments

SIMMS MOTOR UNITS, Ltd., has announced that Mr. Harold George Dunn, M.I.Mech.E., has been appointed to the board of directors. He has been an associate director since January 1, 1958.

MR. R. A. BENT, A.M.I.E.E., has been appointed a director of Lancashire Dynamo Holdings, Ltd.

R. A. LISTER AND CO., Ltd., has announced that Mr. P. Mackay-James and Mr. F. E. Blackstone have been appointed directors.

MR. J. G. P. ANDERSON A.M.I.E.E., has been appointed manager of the development and research department of Crompton Parkinson, Ltd.

MR. H. CARTWRIGHT has been appointed superintendent of the Leeds sales region of A.E.I. Lamp and Lighting Company, Ltd., in succession to Mr. E. Jolley who is to retire later in the year.

MR. VAL PAGE, M.I.Mech.E., chief designer of Ariel Motors, Ltd., is to retire after more than fifty years in automotive engineering. Mr. Bernard Knight is to succeed Mr. Page as chief designer.

VICKERS, Ltd., announces that Mr. Reginald C. Pearse has been appointed an additional director of Canadian Vickers, Ltd., and to the office of president of that company. He will take up his duties as president on May 1.

DR. J. A. L. BONNELL, senior medical officer to the Central Electricity Generating Board, has been appointed nuclear medical officer and deputy to Mr. C. A. Adams, chief nuclear health and safety officer of the Board.

MR. HAROLD W. SECKER has been appointed a director and chairman of the Ketton Portland Cement Co., Ltd., and Mr. Rawson F. Stagg, managing director. Mr. Stagg has also been appointed chairman of the Shap Granite Company, Ltd.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., announces that Mr. G. K. Hampshire, chairman of the general chemicals division, and Dr. J. S. Gourlay, chairman of the paints division, have been appointed to the board of directors with effect from February 2.

MR. ARNOLD CARR, deputy chairman of Thos. W. Ward, Ltd., has been appointed chairman of the subsidiary companies, Thomas Smith and Sons (Rodley), Ltd., John Smith (Keighley), Ltd., and Widnes Foundry and Engineering Company, Ltd.

THE GENERAL ELECTRIC COMPANY, Ltd., has announced the following appointments within its lighting division : Mr. D. W. Durrant, commercial manager ; Mr. C. Dykes-Brown, sales manager ; Mr. D. A. Hart, manager, exterior lighting section.

THE A.E.I.-JOHN THOMPSON NUCLEAR ENERGY COMPANY, Ltd., has announced the following appointments : Mr. S. A. Ghalib, general manager ; Mr. J. R. M. Southwood, chief engineer ; Mr. B. M. Bonfield, secretary, and Mr. A. R. Laing, assistant secretary.

BRITISH INDIA STEAM NAVIGATION COMPANY, Ltd., announces that the Rt. Hon. the Earl of Inchcape, a director of the company, has been appointed a deputy chairman. Mr. W. J. Campbell and Mr. C. S. Munday, also directors of the company, have been appointed managing directors.

DR. SYDNEY JONES, A.M.I.E.E., head of the armament department of the Royal Aircraft Establishment of the Ministry of Supply, has been appointed director of research and development (electrical) of the Central Electricity Generating Board with effect from February 2.

SIR VICTOR G. SHEPHEARD, M.I.N.A., has been appointed director of research of the British Shipbuilding Research Association in succession to the late Dr. S. Livingston Smith. The appointment has been made for an interim period until such time as a permanent appointment can be made.

THE METAL BOX COMPANY, Ltd., states that Mr. K. G. Gerber has been appointed senior project engineer responsible for the development of plastic film, in its technical engineering division at Boreham Wood. Mr. J. F. E. Adams has also been appointed a senior project engineer in this division, and will be in charge of the engineering development of moulding processes.

BTR INDUSTRIES, Ltd., announces the following senior appointments : Mr. J. K. Davies to be assistant secretary of the company ; Mr. E. N. Lowe to be general overseas manager in charge of all export activities of the group ; Mr. Ian Keith to be general manager of the hose division of the group ; Mr. C. K. W. Lewis to be home marketing manager, and Mr. J. S. Exley, special assignments manager of the group's belting division. Mr. Lowe has succeeded Mr. A. E. Hughes, who has retired after more than twenty-seven years' service with the group.

VICKERS, Ltd., announces the following changes in organisation ; Lieutenant-Commander R. B. Lakin, R.N. (Retd.) has been appointed a special director of Vickers-Armstrongs (Engineers), Ltd., and deputy general manager of the Elswick, Scotswood and Wakefield works of that company with effect from February 1. He will relinquish his seat on the board of George Mann and Co., Ltd., on January 31. Colonel H. S. J. Jelf has been appointed a director of George Mann and Co., Ltd., and managing director of that company with effect from February 1, in succession to Lieutenant-Commander Lakin.

SIMON ENGINEERING GROUP announces the following appointments : Mr. G. H. Sugden, Mr. C. H. Wooll, Mr. E. G. Liebert and Mr. J. R. Rowlands have been appointed directors of Henry Simon (Holdings), Ltd. ; Mr. C. G. Ahlquist and Mr. C. W. Jones have been appointed directors of Henry Simon, Ltd. ; Mr. P. W. R. Jolley and Mr. L. Haines have been appointed directors of Simon Handling Engineers, Ltd. ; Mr. F. B. M. Austin has been appointed managing director of Henry Simon (Australia), Ltd., with effect from March 1, 1959, in succession to Mr. K. R. Brocklehurst, who will remain chairman of the company.

Business Announcements

METAL INDUSTRIES, Ltd., states that its address is now Brook House, Park Lane, London, W.1 (telephone Hyde Park 6770).

ALFRED IMHOF, Ltd., announces that the telephone number of its home sales department and works at Uxbridge is now Uxbridge 6231.

MR. F. C. LUNNON, assistant engineer-in-chief of Marconi's Wireless Telegraph Company, Ltd., has retired after forty-seven years' service with the company.

MR. GEORGE WILLIAM RILEY has retired from the boards of George Scott and Son (London), Ltd., and Ernest Scott and Co., Ltd. He will continue to serve the companies as technical consultant.

PRESSED STEEL COMPANY, Ltd., has formed a subsidiary company, Pressed Steel Société Anonyme, Galerie Ravenstein 30, Cantersteen 7, Brussels, 1, to represent it in the Common Market countries.

THE BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION, "SIRA," Southill, Elmstead Woods, Chislehurst, Kent, has opened a new laboratory block to house departments of electronics and electro-optics.

METAL AND PIPELINE ENDURANCE, Ltd., Artillery Mansions, Victoria Street, London, S.W.1, has been appointed official consultant and cathodic protection designer for the Government of Trinidad and Tobago.

THE MUIR ROBB GROUP, Horton Parade, West Drayton, Middlesex, has announced the formation of Road Machines (Sales), Ltd. The new company will absorb the existing home and export departments. Mr. W. Youel and Mr. John Featherstone, home and export sales managers of Road Machines (Drayton), Ltd., will be executive directors of the new company.

FURNIVAL AND CO., Ltd., Waterloo Engineering Works, Stockport, Cheshire, has announced that its sales departments have been transferred to Rhodes, Brydon and Youatt, Ltd., the parent company's offices at Waterloo Engineering Works, Stockport, Cheshire (telephone Stockport 5257/9 and 2625/6). Other departments, including the accounts departments of both companies are now at the Reddish Works (telephone Heaton Moor 4228). Two internal divisions have also been formed to deal with the sale of printing and paper cutting machinery, and with the marketing of the "Andantex" reduction pulleys.

Contracts

PLESSEY INTERNATIONAL, Ltd., has received an order valued at more than £600,000 from the Australian Government for v.h.f. radio communications equipment for use by the Australian Army. The equipment comprises frequency modulated v.h.f. multi-channel radio telephone transmitter/receivers of the types known to the British Army as C42, B47, and B48, all of which have been tried and proved in armoured fighting vehicles under field conditions. The order was received through the National Instrument Company, of Melbourne, the Australian agent of Plessey International, Ltd.

Miscellanea

LIGHTWEIGHT HOIST.—A useful little hoist unit now being made by Haltrac, Ltd., Weimar Street, London, S.W.15, weighs only 1 lb and has a lifting capacity of 1000 lb. It consists of two sets of multiple pulleys coupled through seven strands of nylon cord between which the load is distributed. The pulleys are made of self-lubricating nylon and are mounted in rustproofed housings which incorporate hinged, self-locking hooks. The hooks of each pulley assembly can be used either to sling the hoist or to carry the load, and the 75ft of nylon cord gives the unit a useful working range.

ELECTRIC RESET FOR COUNTERS.—Electromagnetic counters of Type "100" manufactured by Counting Instruments, Ltd., Boreham Wood, Herts, can now be supplied with electrically-operated resetting. For this purpose, a solenoid is mounted at the rear of the case and when momentarily energised operates the resetting mechanism to return the counter reading to zero. With this form of resetting a number of counters can be reset to zero at the same time by operating a push-button switch, which may be situated remotely from the counters. Resetting can be effected while the counter is operating without damage to the counter mechanism.

BIBLIOGRAPHY OF SEMICONDUCTORS.—In publishing its first bibliography of solid state devices four years ago, the Newmarket Transistor Company, Ltd., Exning Road, Newmarket, listed 1115 references. A second issue which has now appeared, with the title *Fifteen Years of Semiconducting Materials and Transistors*, contains 2511 references to papers and articles under the four headings of Semiconductors—Theory and Measurements, Processing of Semiconductors, Rectifiers and Diodes, and Transistors. Authors are indexed alphabetically at the end of the publication. The bibliography has been compiled by Mr. N. L. Meyrick of the company's Research Library.

"DATA PROCESSING."—A new quarterly journal entitled *Data Processing* is published (annual subscription £4) by Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. It is addressed to "top management and chief executives" and is intended to keep them in close touch with progress in data processing and its application to large and small businesses, with the emphasis on commercial and industrial, rather than scientific uses. The contents of the first issue, January-March, 1959, includes an article on "The Universal Language of Computing," and another on "How an Electronic Digital Computer Calculates." A review of electronic digital computers is preceded by a short glossary of computingt erms, but this glossary should be no more than a stand-by provided that the journal adheres to its policy of presenting readable matter with the minimum of jargon.

AUTOMATIC FLUXER FOR BRAZING AND BRONZE WELDING.—A recent development of Weldcraft, Ltd., Purley Way, Croydon, Surrey, is an automatic flux control equipment for use in brazing and bronze welding units. This equipment, it is claimed, in addition to promoting economy in flux eliminates the work entailed in removing flux residue after a job has been welded. With it flux is introduced into the actual flame of a blowpipe and the need for applying paste or powder flux to the work is eliminated. The equipment consists essentially of a chamber containing a cotton wick or filter which is saturated with a highly volatile liquid flux. Gasified flux emitted by the wick is drawn from the top of the chamber by the acetylene as it passes through on its way to the torch and into the flame. The flux being in the flame draws the welding rod quickly into the closest joint and renders unnecessary the use of a large deposit.

PLASTICS-COATED STEEL SHEET.—In THE ENGINEER of October 11, 1957, we reported the introduction, by John Summers and Sons, Ltd., Shotton, Chester, of a plastics-coated steel sheet named "Stelvetite." This material consists of strip mill cold-reduced sheet to which is permanently bonded on one side a sheet of specially formulated P.V.C., the other side of the steel sheet being electro-zinc plated. To demonstrate the progress which has been made with "Stelvetite" in the past fifteen months or so, John Summers and Sons, Ltd., held an exhibition in London last week. At this exhibition there were shown numerous applications of the material in the production of industrial and domestic equipment. "Stelvetite" is produced in steel gauges from 16 B.G. to 26 B.G., in widths up to 4ft, and, generally, in lengths up to 12ft. The material can be supplied in any colour and it is claimed that it can be bent, formed, seamed and deep drawn without damage to the plastics coating.

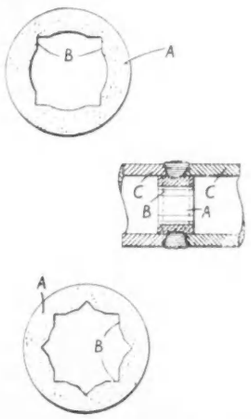
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 51, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

METALLURGY

805,679. February 14, 1957.—WELD BACKING RINGS AND BUTT WELDED JOINTS BETWEEN TUBULAR MEMBERS, Babcock and Wilcox, Ltd., Babcock House, 209/225, Euston Road, London, N.W.1.

The invention relates to weld backing rings and to an improved method of forming butt welded joints between tubular members. The invention includes a weld backing ring for use in forming a circumferential fusion welded joint between adjacent ends of tubular metal members, wherein the material of which the ring is formed comprises a granular, stable, refractory substance and a binder adapted to evolve a weld metal protective atmosphere when subjected to welding heat. The ring is formed with circumferentially spaced weakened portions to facilitate its disintegration after use. Referring to the drawing



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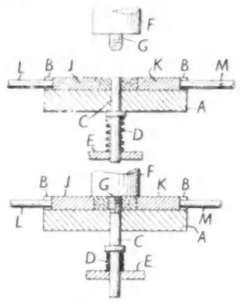
the weld backing rings are of generally annular form with a substantially cylindrical external surface. The ring is provided with circumferentially spaced weakened sections or zones facilitating its impact disintegration after a welding operation is completed. Thus, preferably, as illustrated, notches *B* are formed at circumferentially spaced intervals in the inner periphery of the ring. The ring is formed from any suitable stable refractory granular material, and before moulding is mixed with an organic binder capable of evolving a protective gaseous atmosphere when heated. For example, the granulated material may be bonded with linseed oil which is baked at a temperature and for a time sufficient to oxidise the linseed oil. However, a preferred binder is a synthetic resin suitably of the phenol aldehyde or urea aldehyde type which needs less heating or curing to "set" the binder. In order to unite the two tubes *C* by a butt weld between the ends, the ring is set into the adjacent ends of the tubes which have their abutting edges shaped to form a welding groove. With the ring *A* in place, weld metal is deposited in the groove in any suitable manner, preferably at a high rate. After the welding is completed, the ring is left undisturbed for a short time, until it begins to decompose due to burning out of the resin by the welding heat. The tubes or the weld are then struck with a hammer which shatters the ring, particularly at the weakened portions represented by notches. The fragments of the shattered ring are then easily removed.—*December* 10, 1958.

805,653. January 16, 1957.—THE MOULDING OF NUTS FROM METAL POWDER, John Rigby and Sons, Ltd., Park House Wire Mills, Low Moor, Bradford, in the County of York (communicatees of Charles Robert Talmage, a citizen of the United States of America, Bowery Road, New Canaan, Connecticut, U.S.A.).

This invention relates to the manufacture of nuts by the sintering of metal powders. Its object is to provide an improved method and means whereby any type of nut may be produced from metal powder without risk of rupturing at the thread roots and regardless of how many threads are being moulded at the same time. In the example illustrated in the drawing, the die is designed for the production of plain hexagonal nuts. The stationary lower die *A* and the sides *B* define a trough, into which a central vertical core pin *C* is projected by a spring *D* compressed between a fixed abutment *E* and a stop shoulder on the pin. Directly above, and aligned with, the core pin *C* is a punch *F* with a projection *G* which is externally threaded. Two plunger members *J* and *K* are fitted into the die trough at opposite sides of the pin *C*. As shown in the upper view, iron powder is run in to fill the die cavity defined by the parts *A*, *B*, *C*, *J* and *K*, after the two last-named have been retracted by a suitable amount from the pin and the punch *F* has been fully raised. Subsequently the punch *F* is brought down to the position shown in the lower view to overlie the die sides, the threaded projection *G* pushing down the spring-loaded core pin. With the parts held firmly in position, heavy pressure is exerted upon the plunger members *J* and *K* (for example, by the rods *L* and *M*) to advance



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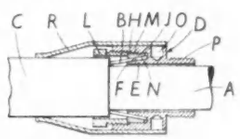
them equally towards the core pin. These members *J* and *K* are shaped to re-entrant "Vs" at their adjacent ends, so that when at the inward limits of their respective travels, they will co-operate with the die sides *B* to give the diminished die cavity a hexagonal profile. They cause the metal powder to be compacted around the punch projection *G* and thus mould the desired threads at the inner periphery of the mass. After sufficient pressure has been applied to produce the desired properties in the moulded nut, the punch is raised, carrying with it the moulded nut, which can then be screwed off the threaded projection. On completion of the operational cycle, the metal powder from which the nut has been moulded is compacted to a sufficient degree of uniformity to ensure that, on final sintering, a product of good strength is obtained. Whilst ordinarily it is desirable to bring the punch *F* into engagement with the die sides *B* before the plunger members *J* and *K* start their inward movement, such timing is not absolutely essential, and if desired the inward travel of the plunger members may commence whilst the punch *F* is still moving, so long as the latter reaches its predetermined final position before the lateral compression of the powder is completed.—*December* 10, 1958.

ELECTRICAL ENGINEERING

805,850. December 11, 1956.—TERMINATING GLANDS FOR ARMOURED ELECTRIC CABLES, W. T. Henley's Telegraph Works Company, Ltd., 51–53, Hatton Garden, London, E.C.1, and Ernest Moor, "Compton," Scarborough Drive, Minster, Sheerness, Isle of Sheppey, Kent.

Referring to the drawing, *A* is an electric cable and *B* the armouring wires, and *C* an outer corrosion-resisting covering. The gland comprises a body *D* having an inner sleeve *E*, the outer wall *F* of which is coned. The bore of the inner sleeve *E* is of a diameter just to accommodate the cable. The



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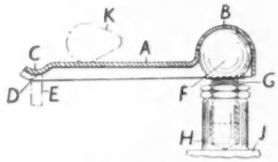
body also includes an outer sleeve *H* which surrounds, but is radially spaced from, the inner sleeve *E* so as to form an annular groove *J*. The outer sleeve *H* is internally threaded and receives a clamping screw *L*. A clamping ring *M* is internally coned at *N* and is slidable in the annular groove *J*. The body is provided with a number of circumferentially spaced recesses *O* arranged to receive the end of a tommy-bar and also with a threaded shank *P* arranged to screw into a box. A shaped shroud *R* of polyvinyl chloride encases the gland and part of the cable and excludes dirt and moisture from the assembly. The use of the gland in making a termination is as follows: the body is screwed into a box and is tightened in position by a tommy-bar. The cable end is stripped so as to extend beyond the armouring *B*, and the armouring is stripped to extend beyond the outer covering *C*. The shroud *R* and clamping screw *L* are pushed over the cable and the clamping ring is slipped over the exposed part of the armouring. The cable is then entered into the body of the gland so as to pass down the bore of the inner sleeve *E* and the exposed armouring *B* enters the annular groove *J*, as shown. The cable is pushed home until the free end of the exposed armouring is hard against the closed end of the annular groove *J*. The clamping ring *M* is then pushed into the groove by the clamping screw *L*. The armouring is thus clamped between the coned outer wall *F* of the inner sleeve *E* and the coned inner surface *N* of the clamping ring *M*, as shown in the drawing. The termination is completed by sliding the shroud *R* to cover the entry of the cable into the gland.—*December* 17, 1958.

INTERNAL COMBUSTION ENGINES

806,176. July 6, 1956.—VALVE-OPERATING MECHANISM FOR OVERHEAD VALVE ENGINES, The Austin Motor Company, Ltd., Longbridge Works, Northfield, Birmingham, and Ivan Nicholas Momtchiloff, of the company's address.

Referring to the drawing, the valve-operating rocker is a steel pressing comprising a channel section stem portion *A* with a hemispherical seating *B* at one end and a convex portion *C* at the other end. During the pressing operation the end of the stem remote from the hemispherical seating *B* is given a part-cylindrical form to afford a convex contacting surface *D* for the upper end of the valve stem *E*. The depending flanges of the channel section stem of the rocker flank serve as guiding or locating means for preventing



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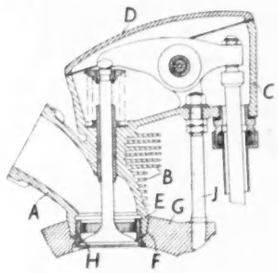
lateral displacement of the rocker from the valve stem. The seating *B* fits over a spherical fulcrum or ball *F* having a stem *G* which screws into a vertical bore in a boss *H* cast at an appropriate position on the cylinder head *J*. By screwing the ball *F* up or down the angular position of the rocker stem in relation to the actuating cam *K* can be adjusted to vary the valve clearance.—*December* 23, 1958.

806,393. August 20, 1956.—THE CONSTRUCTION OF INTERNAL COMBUSTION ENGINES, Davey, Paxman and Co., Ltd., Standard Ironworks, Colchester, Essex. (*Inventors: David Maresco Pearce and John Stent.*)

The invention relates to the construction of internal combustion engines having detachable inlet and/or exhaust passages, its object being to provide an improved detachable passage structure designed for simplicity and ease of attachment and also to simplify



No. 806,393

the casting and machining of the cylinder head of the engine. The cylinder head of the casting is in the form of an exhaust passage *A*, with cooling fins *B*, and a valve gear casing *C* closed by a cover *D*. The passage *A* ends in a hollow, internally threaded spigot *E* which fits a corresponding aperture *F* in the cylinder head *G* and is secured in it by an externally threaded ring *H*. This ring is screwed into the aperture *F* from the inside of the cylinder until its shoulder engages a corresponding shoulder on the cylinder head. The inner end of the ring is shaped to provide a seating surface for an exhaust valve. The stem of the valve extends through a guide sleeve fixed in the passage casting, for engagement by the usual rocker arm. The valve gear casing is mainly supported by

the passage part of the casting, but additional support is afforded by studs *J* screwed into the cylinder head. This additional support imparts greater rigidity to the whole structure and strengthens it against vibration when the engine is running. It will be understood that the inlet passage is formed in another casting secured upon the cylinder head in identical fashion. —*December* 23, 1958.

Launches and Trial Trips

CAIRNFORTH, closed shelter deck cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for the Cairn Line of Steamships, Ltd. ; length between perpendiculars 430ft, breadth moulded 59ft 9¼in, depth moulded to upper deck 38ft 6in, deadweight 10,700 tons on 27ft 6¼in draught ; five holds, three 40kW steam-driven generators ; Hawthorn-Doxford oil engine of 4400 b.h.p. Trial November 13.

STREAMBANK, cargo liner ; built by William Doxford and Sons (Shipbuilders), Ltd., for the Bank Line, Ltd. ; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded to upper deck 38ft 6in, deadweight 12,120 tons on closed shelter deck draught ; five holds, one 25-ton, four 10-ton and ten 5-ton derricks ; Doxford oil engine, four cylinders 700mm diameter by 2320mm combined stroke, 4800 b.h.p. Trial November 17.

CARRIGAN HEAD, cargo ship ; built by Harland and Wolff, Ltd., at Belfast for The Ulster Steamship Company, Ltd. ; length between perpendiculars 430ft, breadth moulded 61ft 6in, depth moulded to shelter deck 39ft 6in ; two complete steel decks, eight watertight compartments, five cargo holds, four 10-ton and twelve 5-ton derricks, electric winches ; one 300kW turbine-driven and two 200kW diesel-driven generators ; one set of double reduction geared two-cylinder turbines, 6000 service s.h.p. at 112 propeller r.p.m. ; steam supplied at 425 lb per square inch and 750 deg. Fah. by two Babcock and Wilcox water-tube boilers. Trial November 18.

TABOA, cargo ship ; built by the Chantiers Réunis Loire-Normandie (Grand Quevilly) for the Compagnie Maritime des Chargeurs Réunis ; length between perpendiculars 433ft 1in, breadth moulded 61ft, draught 24ft 1½in, deadweight 8000 tons ; one 50-ton, one 25-ton and eighteen 5-ton derricks ; speed 16 knots ; Sulzer mark 9 SD.72 diesel engine. Trial November.

ISSELIA, oil tanker ; built by the Chantiers de l'Atlantique Penhoët-Loire for the Compagnie Maritime Shell ; length between perpendiculars 685ft 9in, breadth moulded 97ft 5¼in, depth 49ft 2¾in, draught 36ft, deadweight 42,000 tons ; thirty-three tanks, designed speed 16·3 knots ; one set double reduction geared C.E.M.-Parsons turbines 13,750/15,000 s.h.p., two Foster-Wheeler boilers supply steam at 710 lb per square inch and 860 deg. Fah. Trial November.

KONGSDAL, oil tanker ; built by the Ateliers et Chantiers de la Seine Maritime for Moltzan Tanksrederi, Oslo ; length between perpendiculars 538ft 10in, breadth moulded 73ft 8¾in, depth 40ft 6in, draught 30ft 9in, deadweight 20,100 tons, service speed 15·5 knots ; two 380kW diesel-driven and one 100kW diesel-driven generators ; Burmeister and Wain mark 774 VTRF 160 supercharged seven-cylinder single-acting two-stroke diesel engine, 8750 h.p. at 115 r.p.m. Trial November.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Jan. 23.—OXFORD AND DISTRICT BRANCH: Malborough Club, Didcot, "Relays and Automatic Control in Industry," W. L. Stern, 7.30 p.m. ★ STOKE AND CREWE BRANCH : Grand Hotel, Hanley, "Electronics," F. H. Fryer, 7.30 p.m.

Tues., Jan. 27.—LONDON NATIONAL LECTURE : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Impact of the N.J.C.E.I.C. on the Electrical Contracting Industry," E. J. Sutton, 6.30 p.m.

Thurs., Jan. 29.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, "Switchgear for Automation," 7.30 p.m.

Mon., Feb. 2.—BOLTON BRANCH : Railway Hotel, Trinity Street, Bolton, "Refrigeration," 7.45 p.m. ★ LEEDS BRANCH : Great Northern Hotel, Leeds, "Process Heating," 7.30 p.m. ★ N.E. LONDON BRANCH : Angel Hotel, Ilford, "Insurance and the Electrical Engineer," L. G. Warner, 8 p.m. ★ SHEFFIELD BRANCH : Royal Victoria Hotel, Sheffield, "Pros and Cons of Floor Heating," H. Chippendale, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Jan. 23.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Inaugural Meeting of the Medical Electronics Group ; Address by A. V. Hill, 6.30 p.m.

Wed., Jan. 28.—LONDON SECTION : University College, London, W.C.1, "Theoretical Aspects of Mechanical Speech Recognition," D. B. Fry, "The Design and Operation of the Mechanical Speech Recognizer at University College, London," P. Denes, 6.30 p.m.

Thurs., Jan. 29.—S.W. SECTION : School of Management Studies, Unity Street, Bristol, 1, "Recent Developments in Printed and Potted Circuits," H. G. Manfield, 7 p.m. ★ S. MIDLANDS SECTION : Winter Gardens, Malvern, "Industrial and Underwater Television," B. V. Somes-Charlton, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 26.—LEICESTER CENTRE : E. Midlands Electricity Board, Charles Street, Leicester, "Industrial Lighting," R. H. Sanders, 7 p.m.

Wed., Jan. 28.—CARDIFF CENTRE : University College, Cardiff, "The Eye and Artificial Lighting," W. J. Wellwood Ferguson, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Jan. 26.—W. AND E. YORKSHIRE BRANCH : New Building, The University, Leeds, "The Wilton Project," G. G. Lanham, 7.30 p.m.

Tues., Jan. 26.—S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, Films on "Hyoraulics," 7.30 p.m.

Thurs., Jan. 29.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, "Incentives in Maintenance," J. W. Kingdon, 7.30 p.m.

Fri., Jan. 30.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, Open Forum, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Jan. 28.—LONDON BRANCH : Constitutional Club, Northumberland Avenue, London, W.C.2, Apprentices' Evening : "Bring Your Problems," A. Talbot, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Jan. 27.—Memorial Building, 76, Mark, Lane, London, E.C.3, "Heavy Oil Burning," J. S. Clarke and G. J. Hudson, 5.30 p.m.

Thurs., Jan. 29.—KINGSTON UPON HULL AND E. MIDLANDS SECTION : Royal Station Hotel, Kingston upon Hull, Annual General Meeting, 7.30 p.m.

Mon., Feb. 2.—STUDENT MEETING : Memorial Building, 76, Mark Lane, London, E.C.3, "Discussion on "Watchkeeping, Maintenance, Repair and Survey of Ships," 6.30 p.m. ★ MERSEYSIDE AND N.W. SECTION : Liverpool Engineering Society, The Temple, Dale Street, Liverpool, Annual General Meeting, "Heavy Oil Burning," J. S. Clarke and G. J. Hudson, 6 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Feb. 5.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, "Thermoelectric Cooling," H. J. Goldsmid, 5.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Fri., Jan. 30.—N.W. BRANCH : Midland Hotel, Manchester, Annual General Meeting, 3.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 27.—Great George Street, Westminster, London, S.W.1, "Changes in the Wash as affected by Training Walls and Reclamation Works," Sir Claude Inglis and F. J. T. Kestner, 5.30 p.m.

Tues., Feb. 3.—Great George Street, Westminster, London, S.W.1, "Preliminary Planning for the New Tube Railway Across London," F. S. P. Turner, 5.30 p.m.

Thurs., Feb. 5.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, "Hydraulic Models," F. H. Allen, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 26.—FARADAY LECTURE : Royal Festival Hall, Belvedere Road, London, S.E.1, "Automation," H. A. Thomas, 6 p.m. ★ N.E. CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "Turbo-Generator Performance under Exceptional Operating Conditions," T. H. Mason, P. D. Aylett and F. H. Birch, 6.15 p.m.

Tues., Jan. 27.—E. MIDLAND CENTRE : College of Arts and Crafts, Waverley Street, Nottingham, "Reheat Practice in British Power Stations," F. H. S. Brown and J. W. H. Dore, 6.30 p.m. ★ N.W. SUPPLY GROUP : Engineers' Club, Albert Square, Manchester, "Standardization of Control Facilities for the British Grid : Communications, Indications and Telemetering," P. F. Gunning, "The Development of Communication, Indication and Telemetering Equipment for the British Grid," G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning, 6.45 p.m.

Wed., Jan. 28.—SUPPLY SECTION (in conjunction with the British Nuclear Energy Conference) : Savoy Place, London, W.C.2, "The Design of Electro-Mechanical Auxiliaries Directly Associated with Power Producing Reactors," A. E. Harwood, P. Scott and B. H. Stonehouse, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to Evershed and Vignoles, Ltd., Acton Lane, London, W.4, 2 p.m. ★ RUGBY SUB-CENTRE : College of Technology and Arts, Rugby, "Electrical Installation at Calder Hall Nuclear Power Station," N. J. Mackay and E. Hardwick, 6.30 p.m.

Thurs. and Fri., Jan 29 *and* 30.—RADIO AND TELECOMMUNICATION SECTION : Convention on Long-Distance Transmission by Waveguide.

Thurs., Jan. 29.—S.W. SUB-CENTRE : County Museum, Royal Institution of Cornwall, Truro, "The Use of Nuclear Fuel for Industrial Purposes," Sir Christopher Hinton, 7.30 p.m.

Mon., Feb. 2.—MERSEYSIDE AND N. WALES CENTRE AND N.W. CENTRE : Town Hall, Chester, "Electrification of the U.K.A.E.A. Industrial Group Factories," J. W. Binns and W. J. Outram, 6.30 p.m. ★ N.E. RADIO AND MEASUREMENT GROUP : King's College, Newcastle upon Tyne, "Subscriber Trunk Dialling," D. A. Barron, 6.15 p.m. ★ S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "The Teaching of Electrical Network Theory," opened by D. G. Tucker and J. T. Allanson, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Thurs., Jan. 29.—YORKSHIRE BRANCH : Midland Hotel, Bradford, "Management and Productivity," R. H. Harrison, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 27.—39, Elmbank Crescent, Glasgow, "Applications of Wave Resistance Theory to Problems of Ship Design," G. Weinblum, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Jan. 27.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Informal Meeting, Films, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 23.—ORDINARY MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, Thomas Lowe Gray Lecture : "Marine Refrigeration," H. R. Howells, 6 p.m.

Tues., Jan. 27.—EASTERN BRANCH : North Herts Technical College, Letchworth, "Quality in Engineering," F. Nixon, 7.30 p.m. ★ E. MIDLANDS BRANCH : College of Arts and Crafts, Waverley Street, Nottingham, "Reheat Practice in British Power Stations," F. H. S. Brown and J. W. H. Dore, 6.30 p.m. ★ BIRMINGHAM A.D. CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Standards and Standardization in the Motor Industry," E. W. Woodbridge, 6.30 p.m.

Wed., Jan. 28.—EDUCATION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion "The Teaching of the Theory of Structures and Strength of Materials," 6 p.m. ★ SOUTHERN GRADUATES' SECTION : Technical College, Reading, "Transmissions for Small Marine Craft," K. W. Roberts, 7.30 p.m.

Thurs., Jan. 29.—WESTERN A.D. CENTRE : Royal Hotel, Bristol, "Suspension," S. S. Tresilian, 6.45 p.m. ★ E. MIDLANDS GRADUATE SECTION : College of Art, Green Lane, Derby, "Product Planning," G. Blythe, 7.15 p.m. ★ N.W. BRANCH : Engineers' Club, Albert Square, Manchester, "Reheat Practice in British Power Stations," F. H. S. Brown and J. W. H. Dore, 6.45 p.m.

Fri., Jan. 30.—ORDINARY MEETING IN CONJUNCTION WITH THE STEAM GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Energy Balance in Steam Power Plant Feed Systems," R. S. Silver, 6 p.m.

Sat., Jan. 31.—LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, "The Design and Development of Machine Tools," C. A. Sparkes, 3 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Jan. 23.—CARDIFF SECTION: South Wales Institute of Engineers, Park Place, Cardiff, "Plant Utilisation and Lower Costs," S. J. Watkins, 7 p.m.

Mon., Jan. 26.—MANCHESTER SECTION : Reynold's Hall, College of Science and Technology, Sackville Street, Manchester, "New Techniques and Improved Equipment in Cotton Mills," E. G. Smalley, 7.15 p.m.

Wed., Jan. 28.—SHREWSBURY SECTION : Technical College, Abbey Foregate, Shrewsbury, "Impact Extrusion and Cold Flow Pressing of Ferrous and Non-Ferrous Metals," H. W. Byles, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Jan. 26.—MANCHESTER SECTION : Grand Hotel, Manchester, "Effects of Irradiation on Polymers and Protective Clothing," A. Quinton, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Jan. 23.—MIDLAND COUNTIES' BRANCH : James Watt Memorial Institute, Birmingham, "Some Modern Examples of Reinforced and Prestressed Concrete Work," A. P. Mason, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 23.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Cutting Fluids," W. R. Steet, 7 p.m.

Fri., Jan. 30.—INFORMAL MEETING : Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Scope of Technical Authorship and Illustration," J. C. Y. Baker, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Jan. 30.—Engineers' Club, Albert Square, Manchester, "Powder Metallurgy," L. Harrison, 6.45 p.m.

MANCHESTER STATISTICAL SOCIETY

To-day, Jan. 23.—Portico Library, 57, Mosley Street, Manchester "Operational Research in the Coal Industry," M. G. Simpson, 6 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Jan. 23.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Sea Trials on a Cargo-Passenger Liner with Block Coefficient 0·672, and on a Large Tanker with Block Coefficient 0·770," G. Aertssen, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

To-day, Jan. 23.—MIDLAND COUNTIES' BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Modern Examples of Reinforced and Prestressed Concrete Works," A. P. Mason, 6.30 p.m.

Thurs., Jan. 29.—WEST OF ENGLAND BRANCH : New School of Engineering, University of Bristol, "Recent Developments in the Design of Shell Roofs," J. D. Bennett, 6 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 4.—John Adam Street, Adelphi, London, W.C.2, "The Mechanization of Building Constructional Processes," D. G. R. Bonnell, 2.30 p.m.

ROYAL SOCIETY OF HEALTH

Wed., Jan. 28.—Civic Centre, Newport, Mon, "Prevention of Four Epidemic Diseases," J. Sleigh, "The Clean Air Act, 1956—Practice and Problem," R. G. Coslett, 10 a.m.

SOCIETY OF ENGINEERS

Mon., Feb. 2.—Geological Society, Burlington House, Piccadilly, London, W.1, Presidential Address, I. C. Cocking, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Jan. 27.—Manson House, Portland Place, London, W.1, Symposium on Flow Measurement : "Ultrasonic Flowmeter," R. E. Fischbacher: "Mass Flowmeters," P. Scanes; "Magnetic Flowmeters," B. W. Bails ; "Propeller Flowmeters (Electronic)," F. R. Allen, 6 p.m.

Wed., Jan. 28.—CHESTER SECTION : Grosvenor Museum, Grosvenor Street, Chester, "Electrical Weighing—Its Technique and Application," K. J. Railler, 7 p.m.

Thurs., Jan. 29.—GRANGEMOUTH SECTION : Leapark Hotel, Grangemouth, "Electronic Weighing," K. J. Railler, 7 p.m.

Fri., Jan. 30.—SCOTTISH SECTION : Building Centre, 425, Sauchiehall Street, Glasgow, "Measurement of Temperature Using Fuel Systems," D. T. Royce, 7.15 p.m.

WOMEN'S ENGINEERING SOCIETY

Fri., Jan. 30.—LONDON BRANCH : Hope House, 45, Great Peter Street, Westminster, London, S.W.1, "Some Uses of Electron Beams in Metallurgy," Mrs. I. H. Hardwich, 7 p.m.

Advanced Engineering Courses

The Design of Equipment for Human Use. ENGINEERING AND ALLIED EMPLOYERS' WEST OF ENGLAND ASSOCIATION, Engineers' House, The Promenade, Clifton Down, Bristol. The course is intended for staff concerned with the design of machines and equipment of all kinds which have to be manually operated or controlled. Two weeks' course, Monday, February 16, to Friday, February 27. Fee £40. Accommodation 25s. per day.

How to Manage and Control Automatic Data Processing. CONNAUGHT ROOMS, Great Queen Street, London, W.C.2. The course will cover all phases of planning, installing and controlling an A.D.P. system with or without the use of computers. One week's course, Monday to Friday, February 9 to 13. Applications should be made to Urwick Diebold, Ltd., 29, Hertford Street, London, W.1. Fee 85 guineas.

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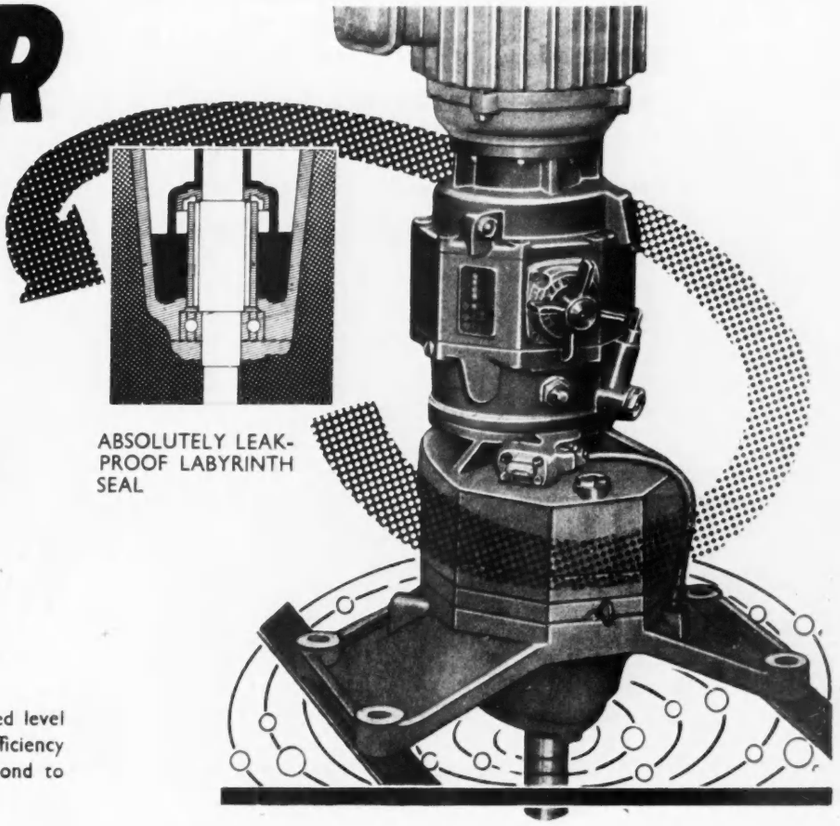

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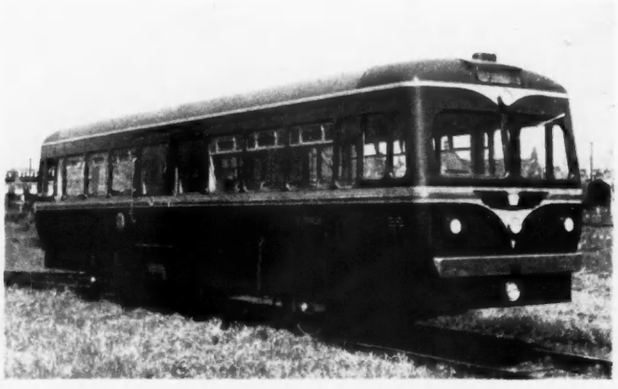

Photograph by courtesy of British Railways

One of two railbuses built by British Commercial Vehicles Ltd. in conjunction with Eastern Coach Works Ltd. for British Railways. The control system was designed by B.C.V. in collaboration with Westinghouse whose pneumatic equipment is used for throttle, gearbox and primary brake control.

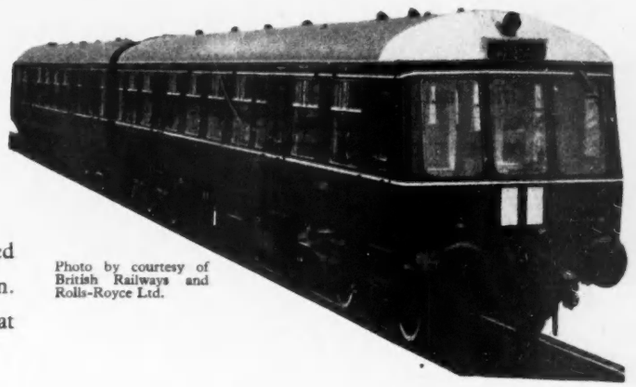

Photo by courtesy of British Railways and Rolls-Royce Ltd.

Rolls-Royce engined railcars for British Railways are fitted with Westinghouse controls for the engines and transmission. This equipment includes a fully graduable control so that any desired engine setting can be obtained.

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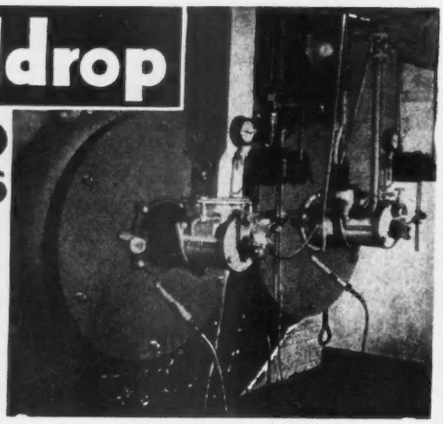

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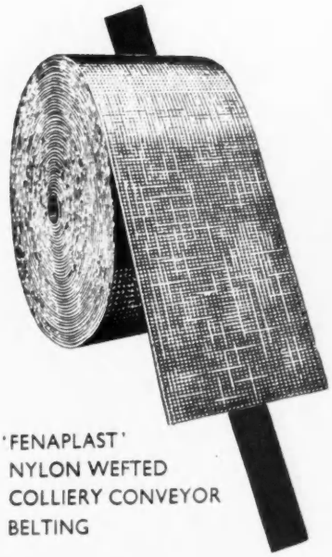

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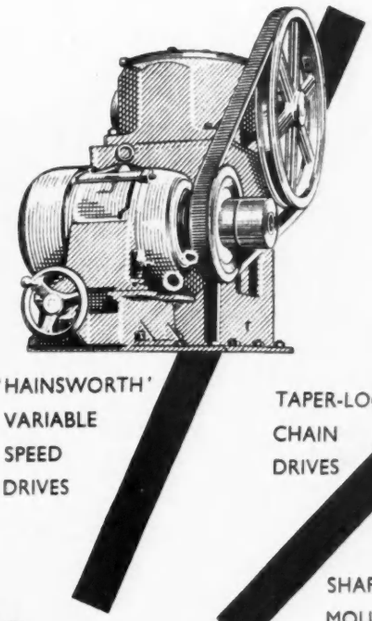

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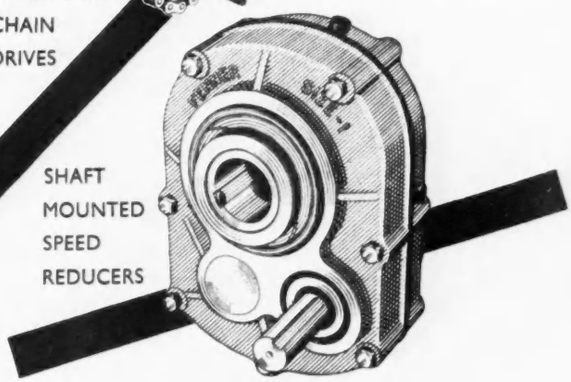

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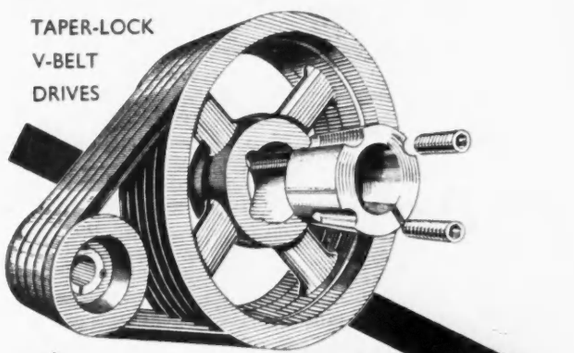

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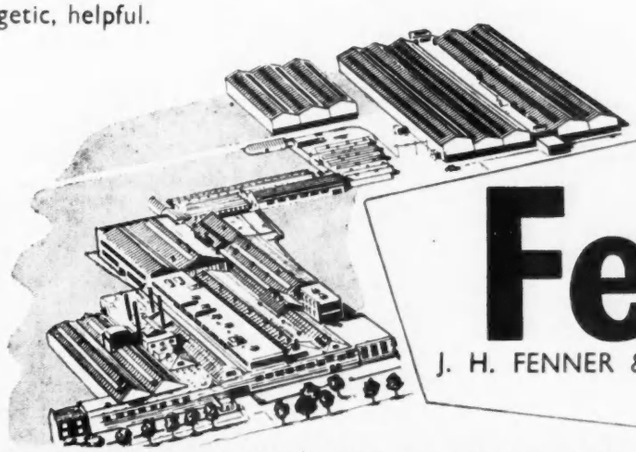

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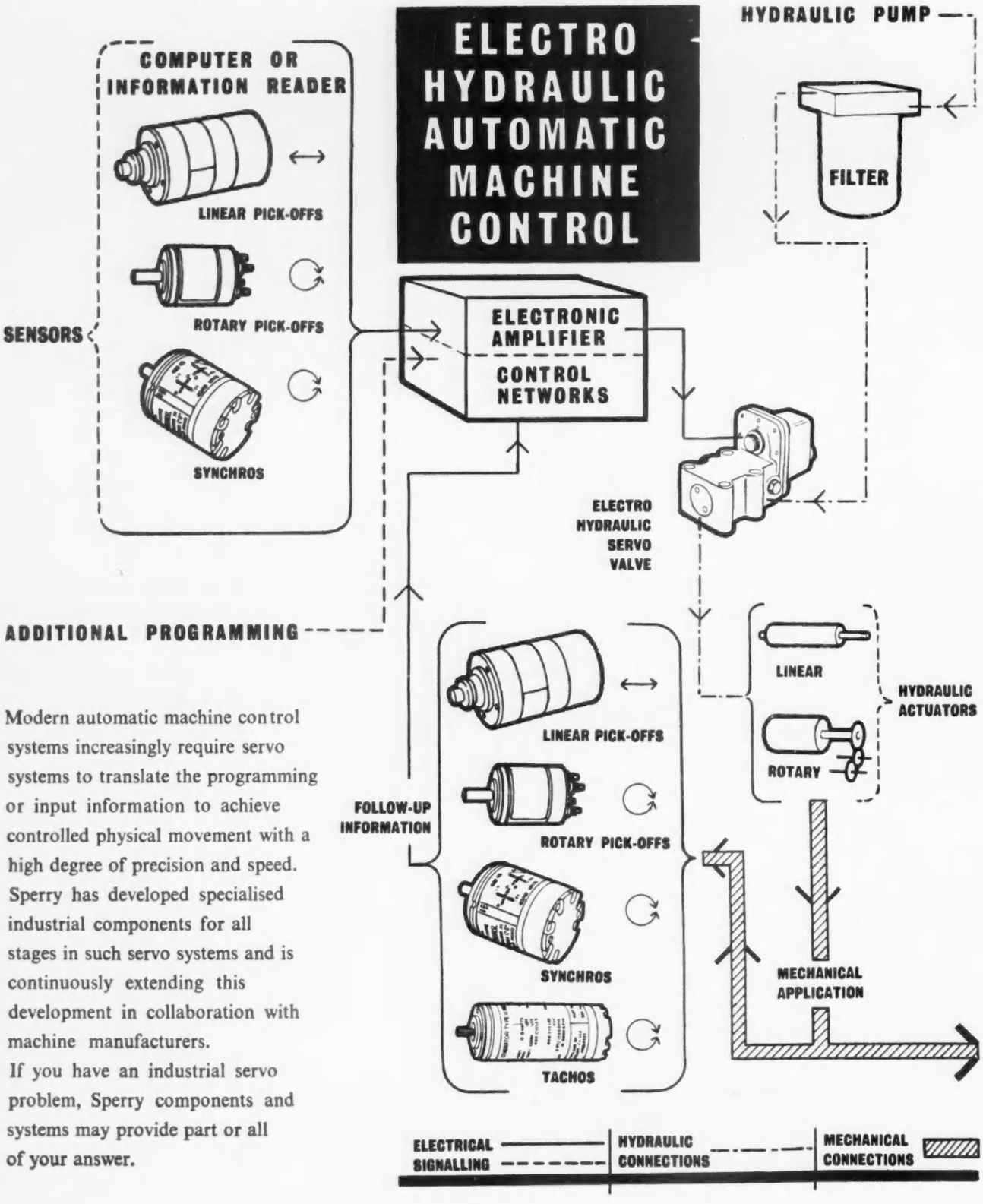

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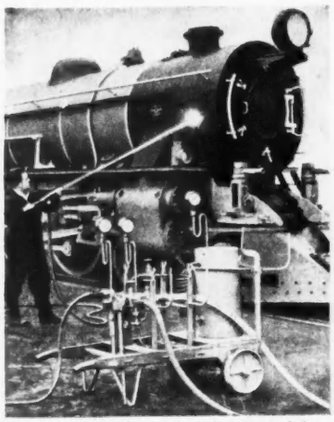

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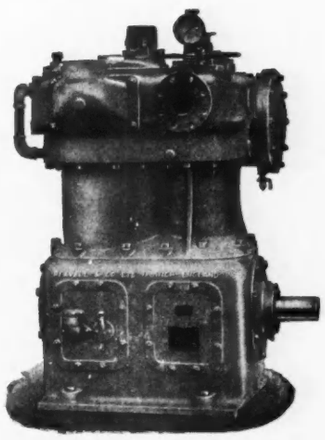

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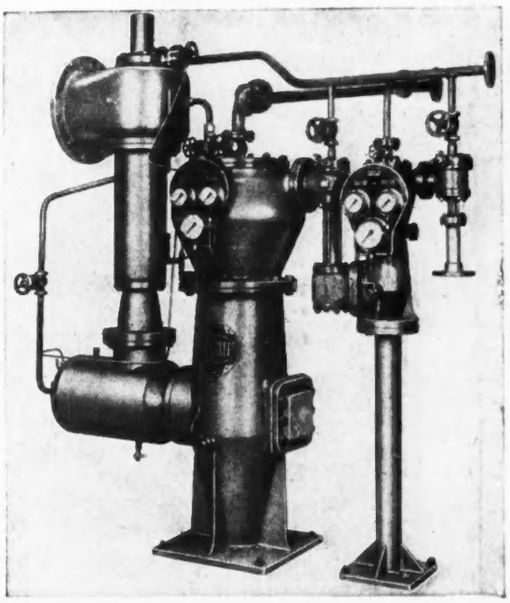

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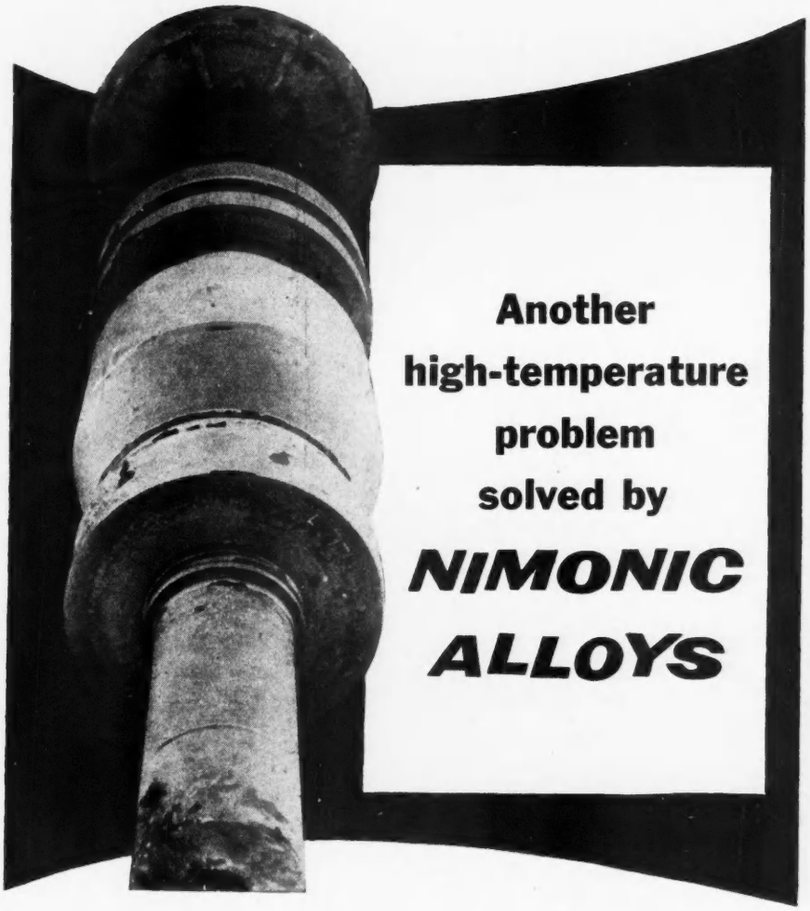

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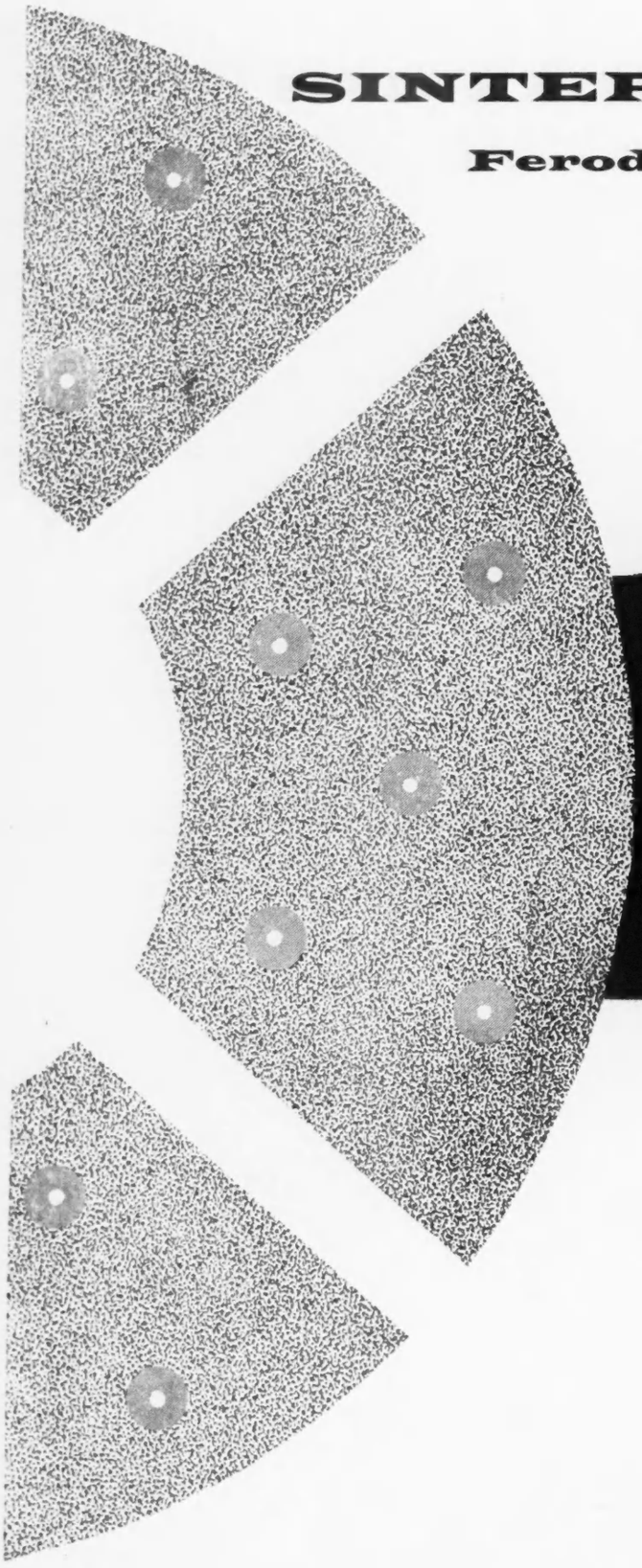

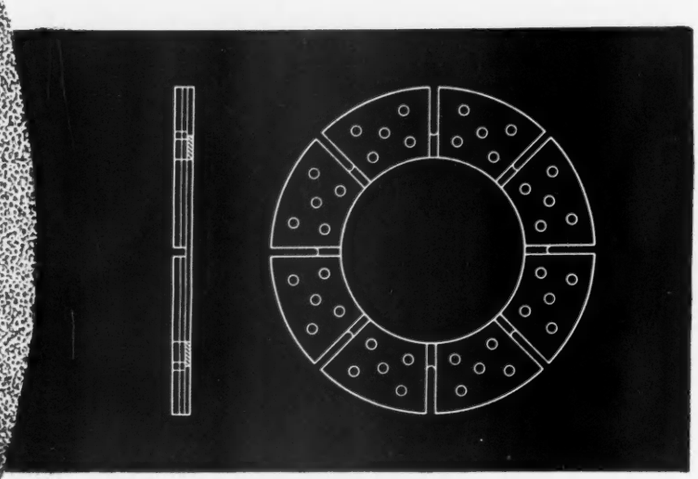

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SM.1 General purpose material for dry and oil immersed applications

SM.2 For oil immersed applications requiring smooth, gradual engagement such as automotive automatic transmissions

SM.3 Specially suited to dry, heavy duty applications such as engine master clutches on trucks and on tractor steering clutches

SM.4 Is intended as a mating surface for use against other Ferodo sintered metals to protect costly parts from heat damage and wear

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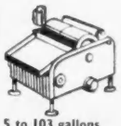

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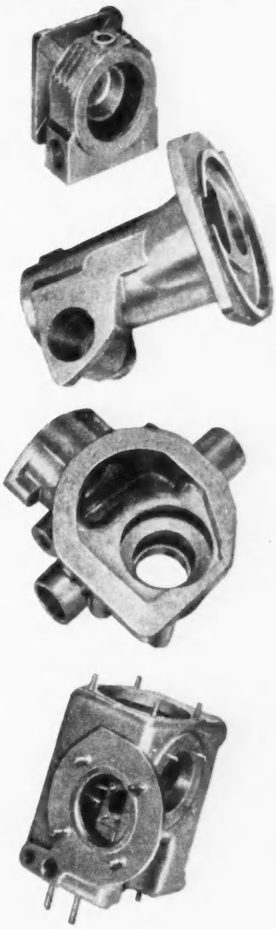

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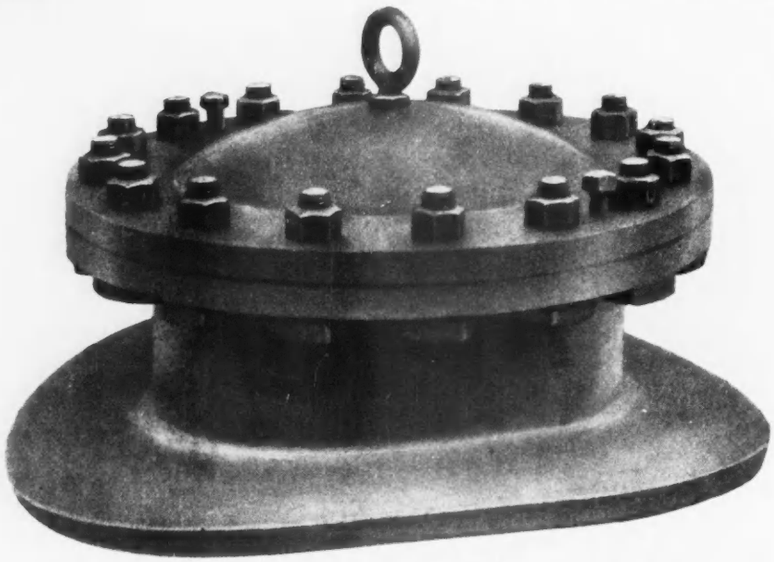

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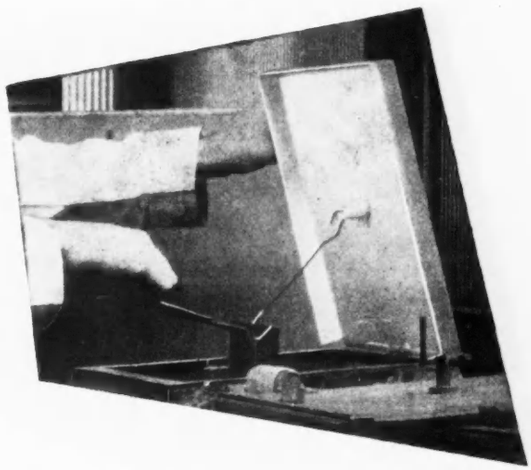

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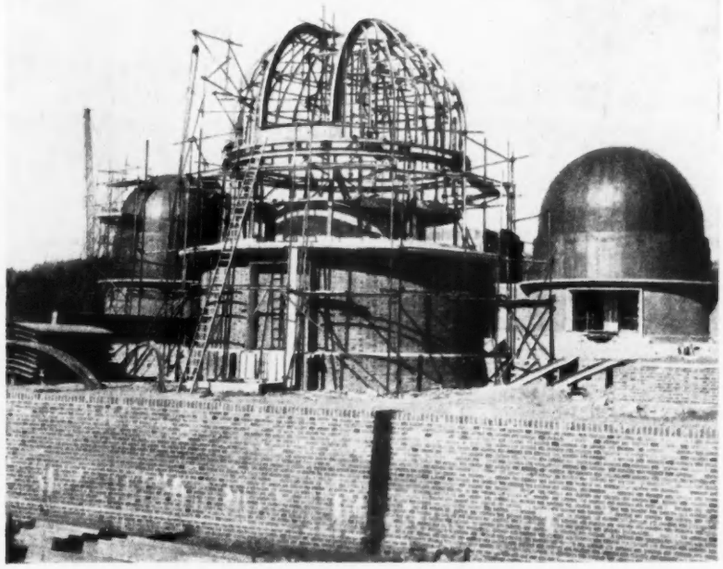

The illustration shows the steelwork supplied for the domes at the Royal Greenwich Observatory, Hurstmonceaux, to the order of Knight Construction, Ltd.

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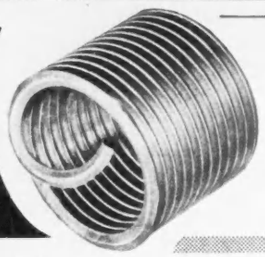

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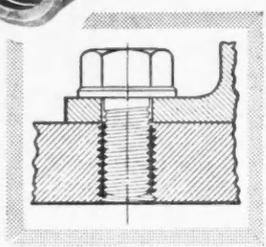

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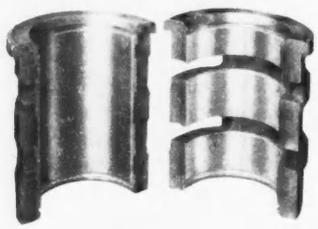

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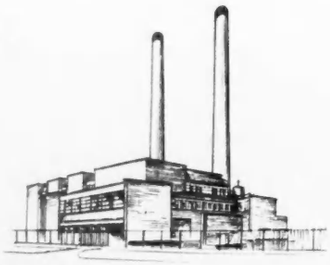

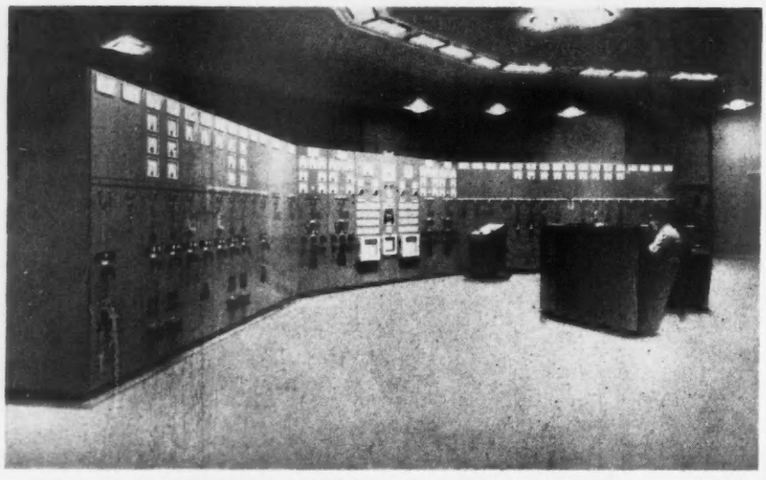

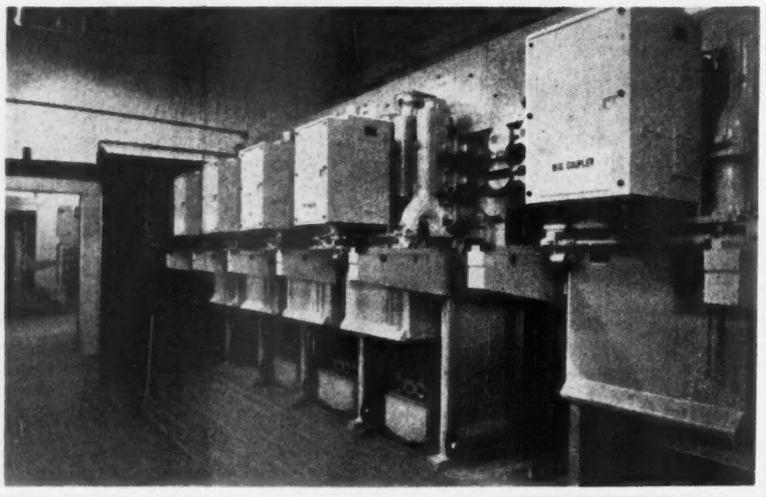

The illustrations show the main 11-kV 350-MVA oil-break metalclad switchgear and main control-board, supplied by Reyrolle, in the new Merseyside Power Station of Lever Bros. Port Sunlight Limited

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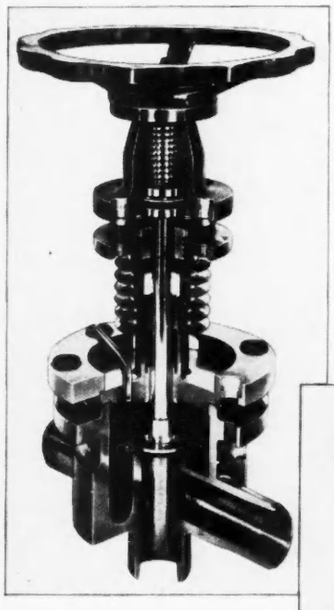

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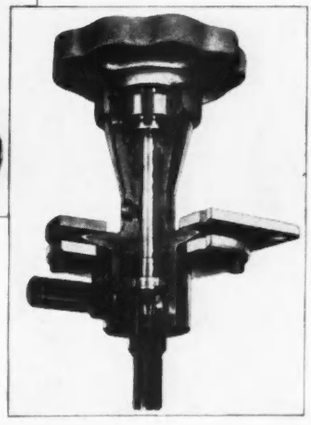

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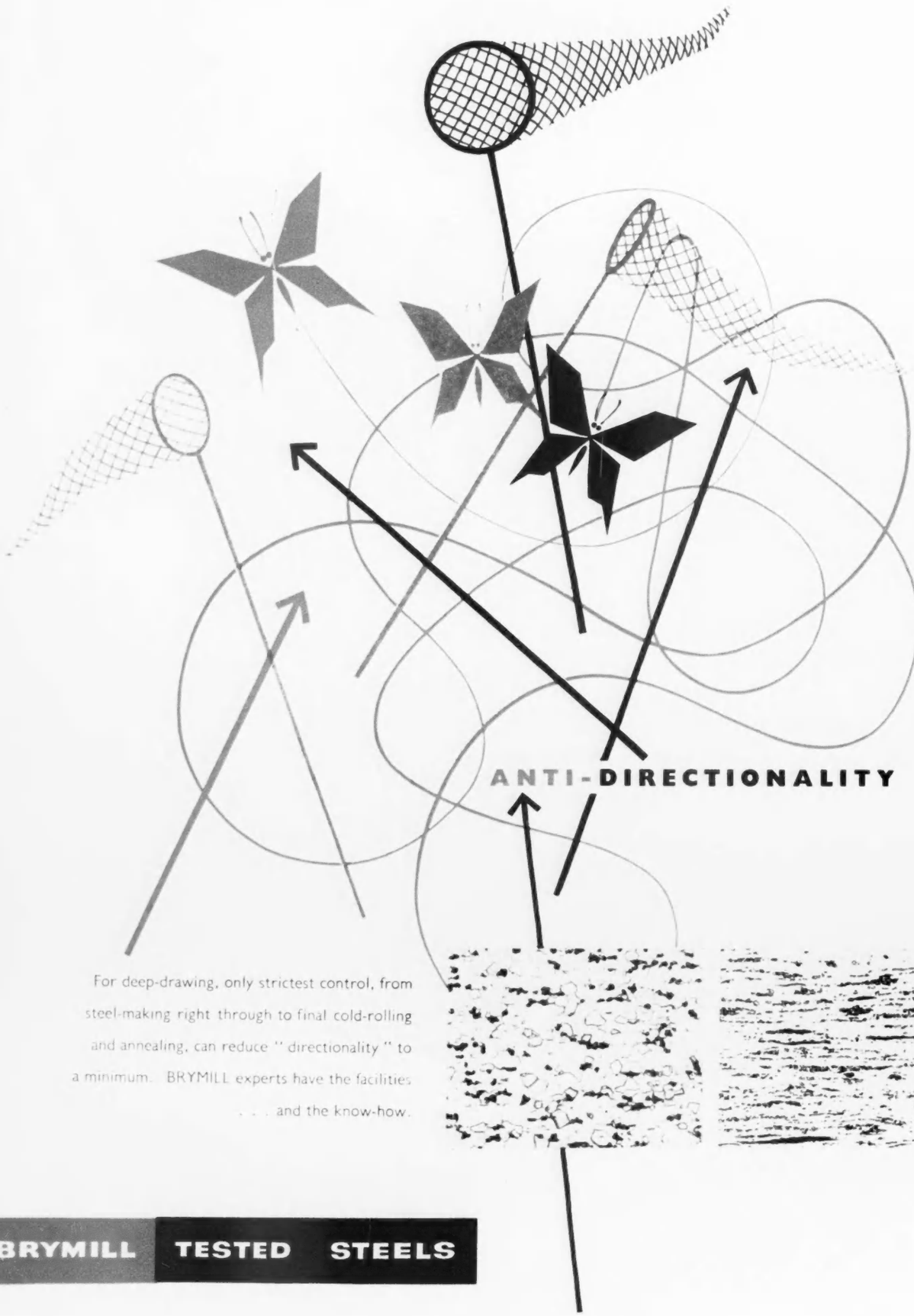

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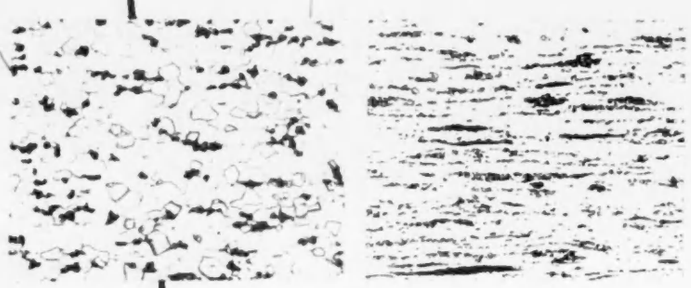

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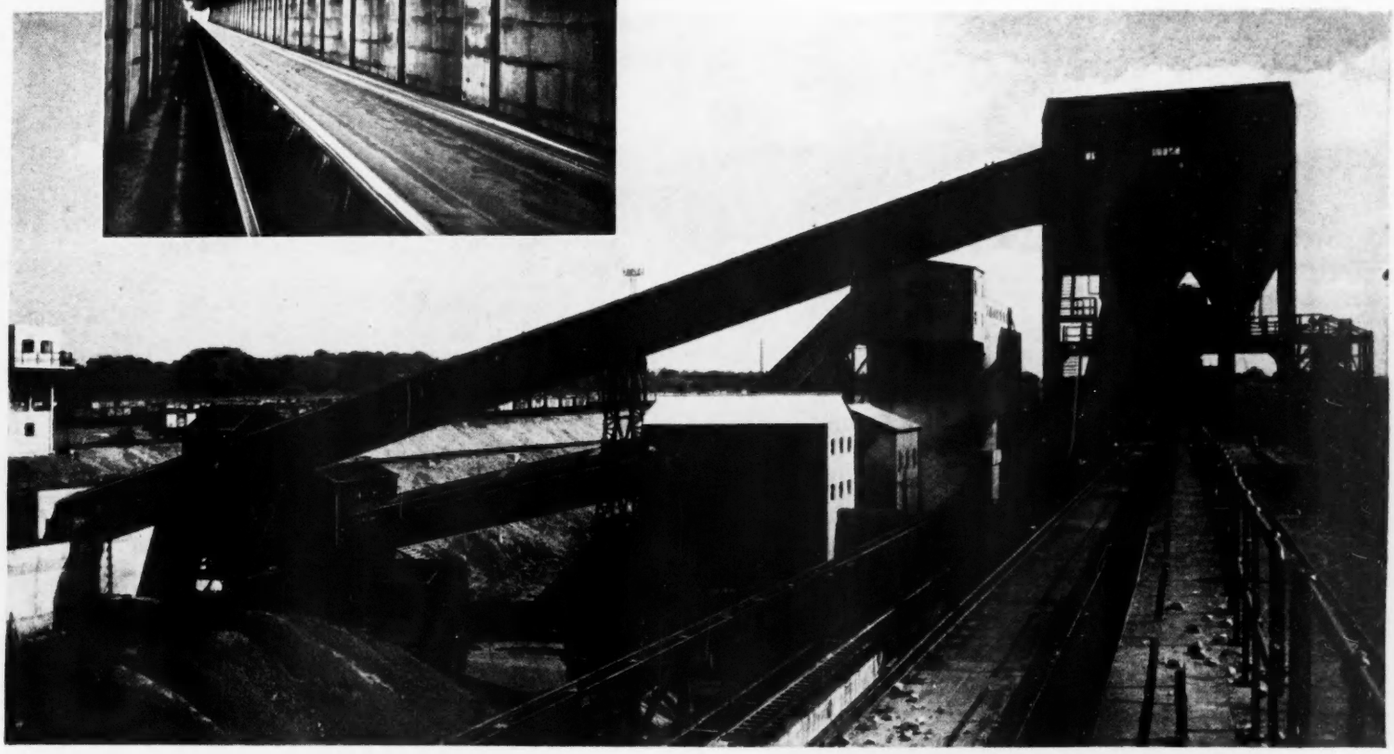
Iron-ore conveyor system at Messrs. Colvilles new plant at Ravenscraig.



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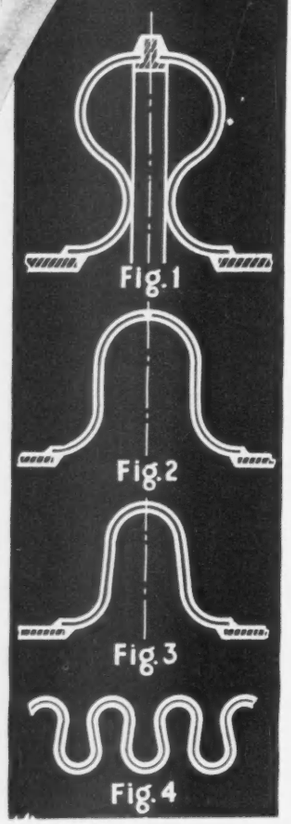

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Fig. 3 A bellows profile which may be formed by deep pressing. This type of expansion fitting is built up in three or more sections with longitudinal welds.

Fig. 4 One of the profiles available for the Aiton "A" type expansion fitting. This unit is made by a special process which obviates the need for circumferential welding at the crown of, and between, convolutions.

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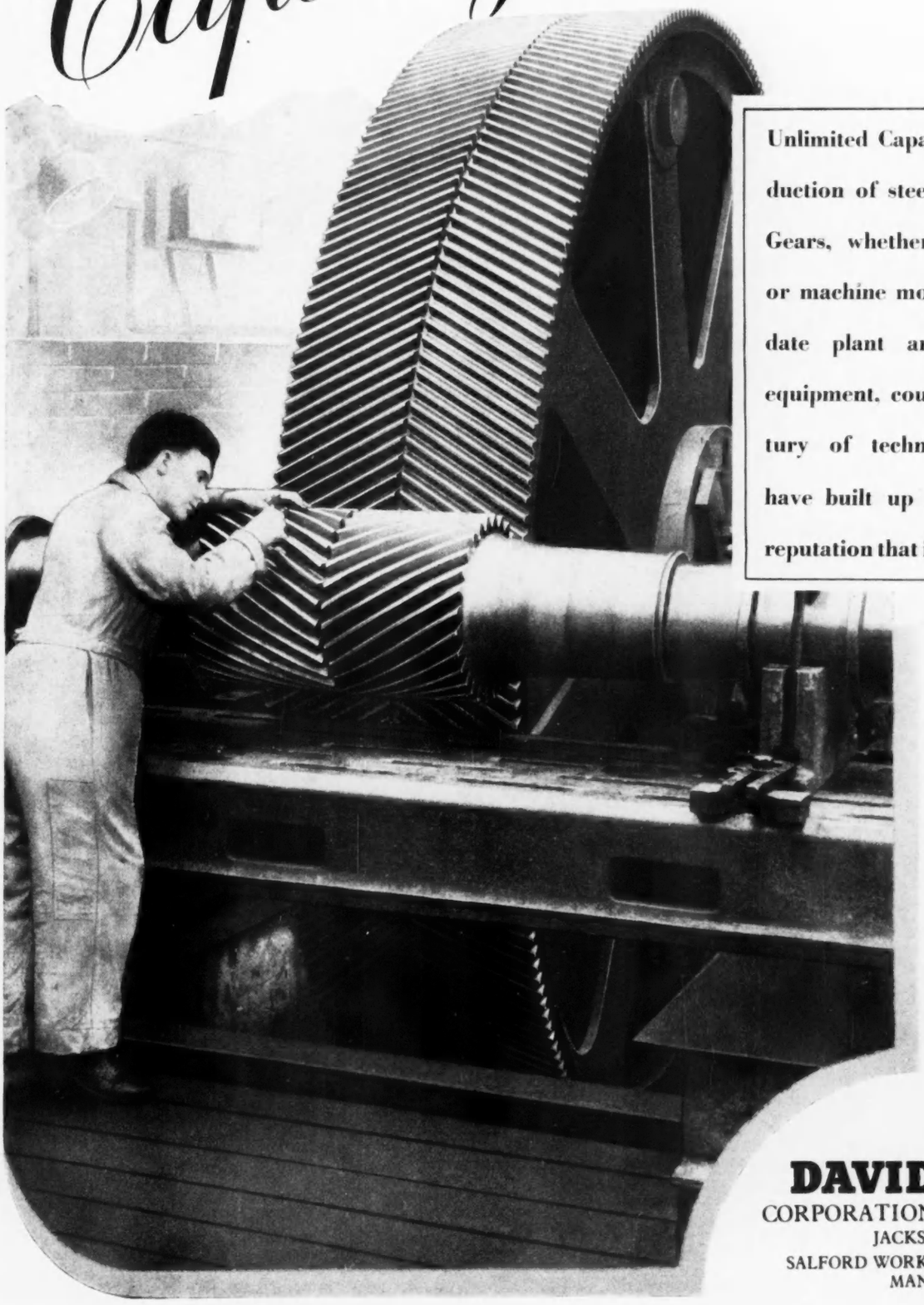

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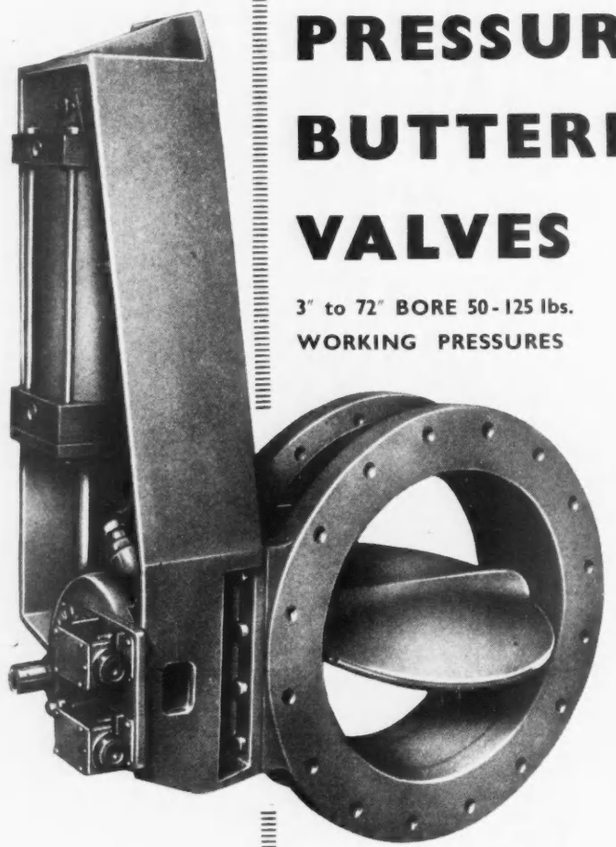

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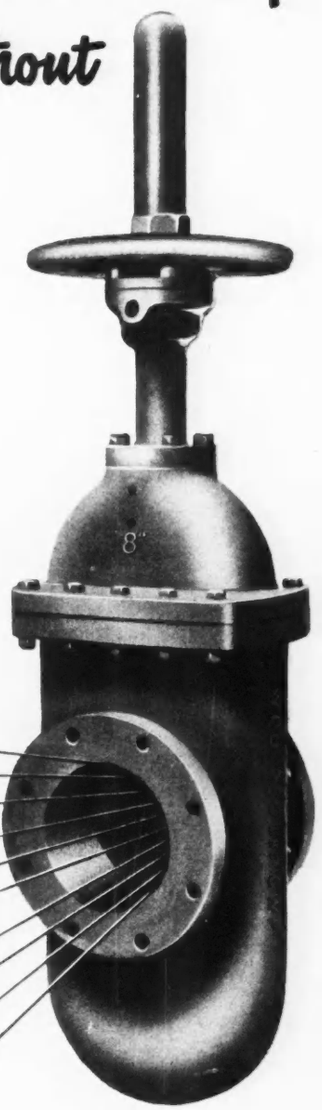

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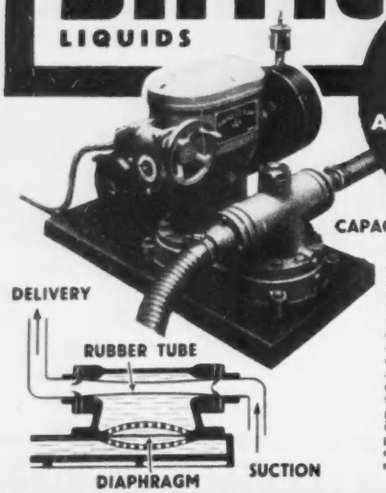

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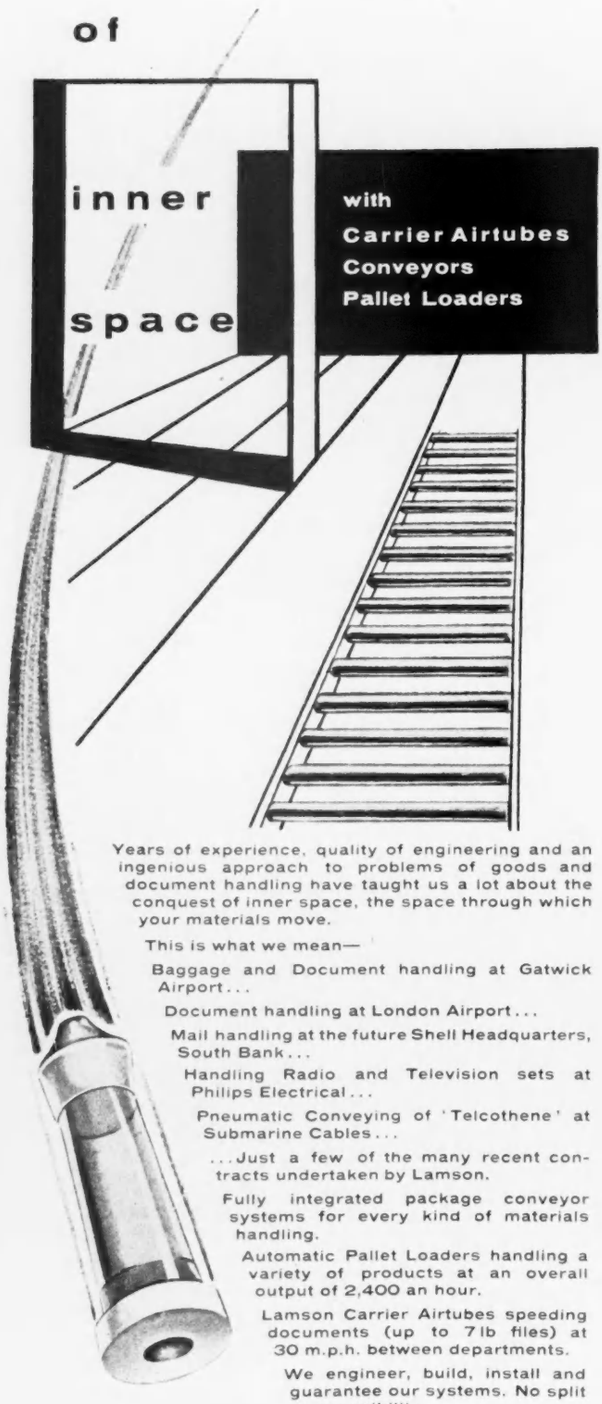

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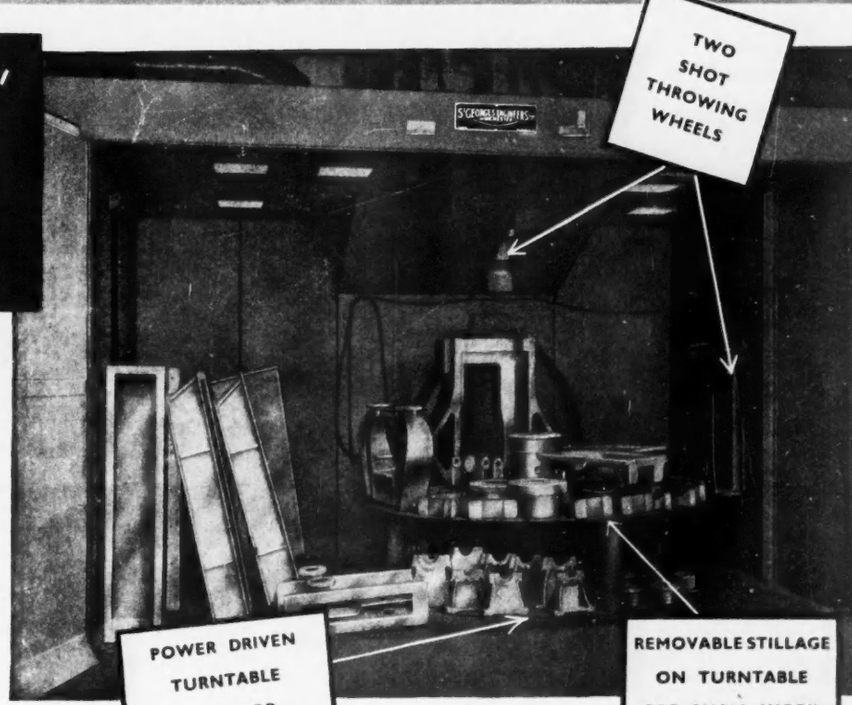

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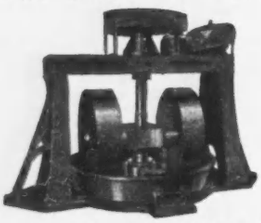

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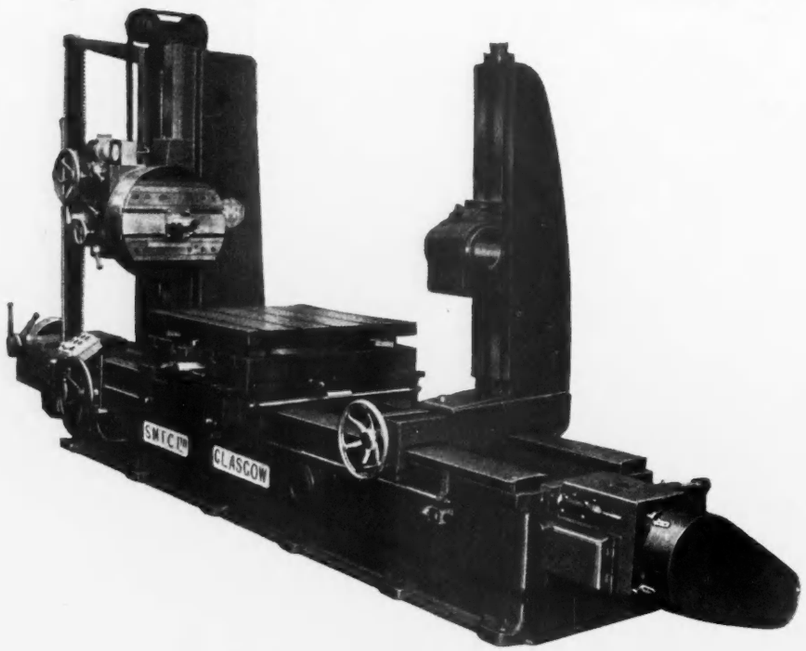

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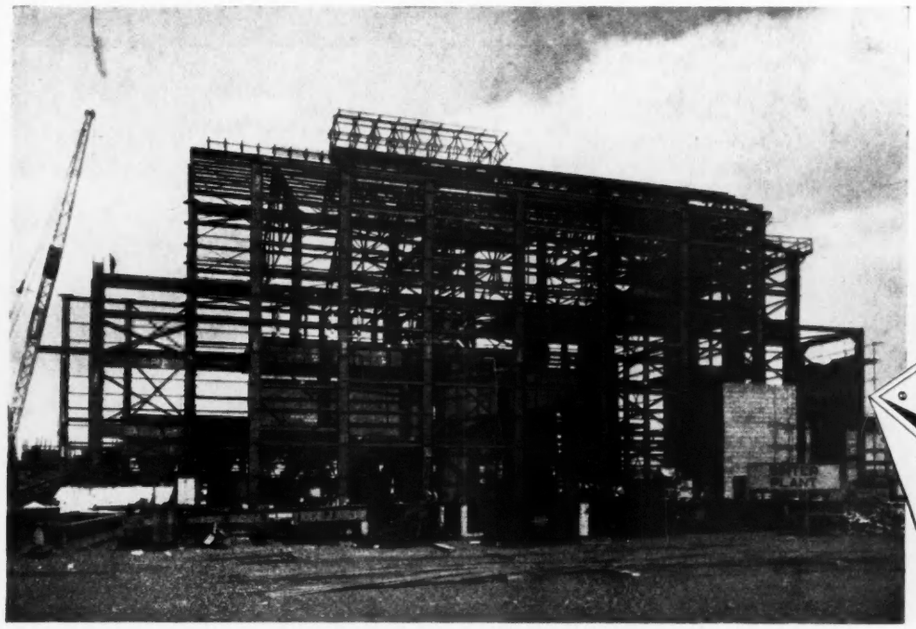

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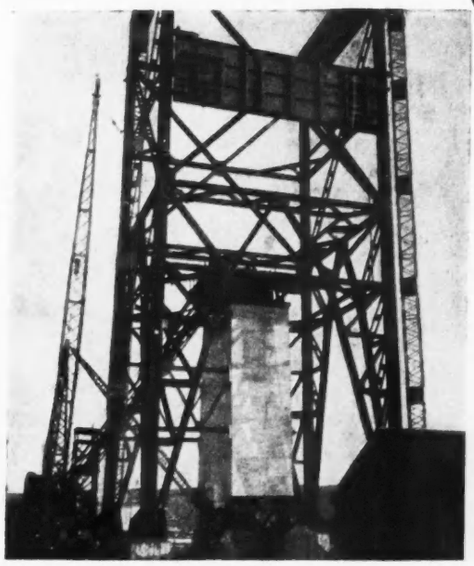

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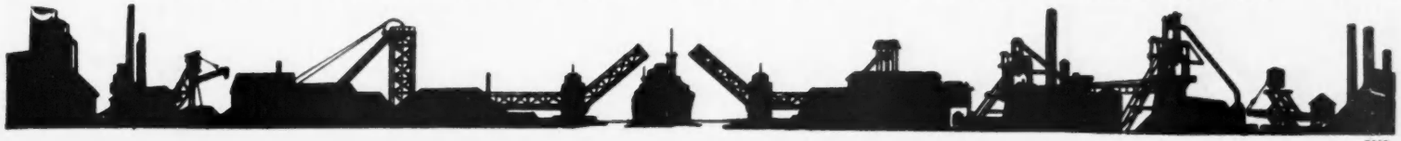

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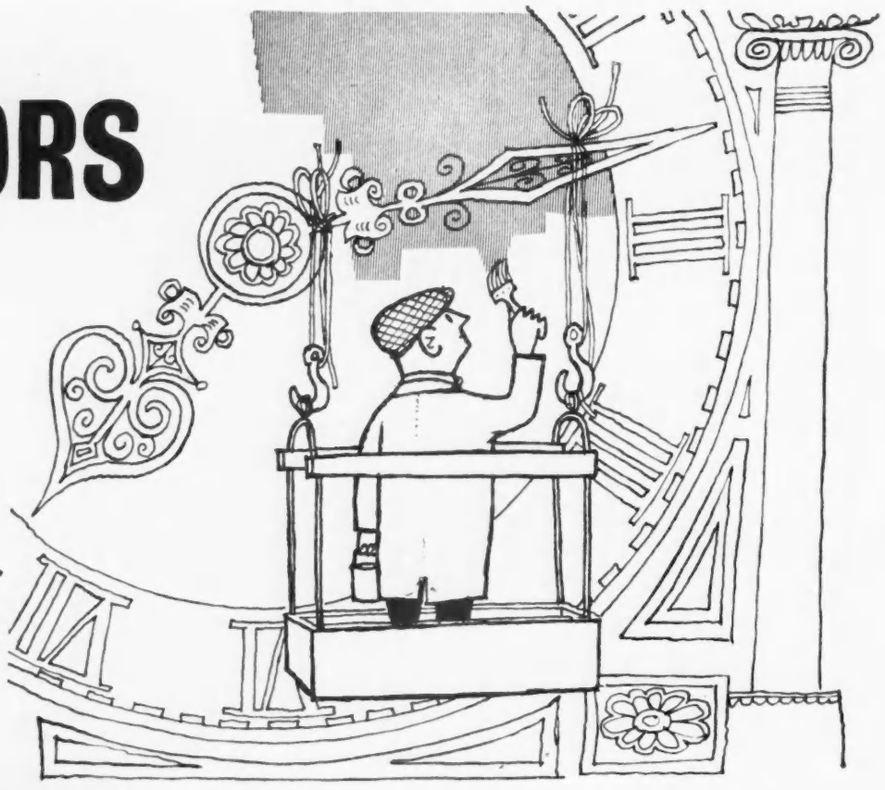

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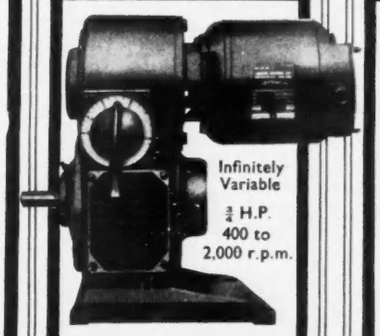

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Compact purpose-made power drives are our business
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Equipment for Coke Ovens, Blast Furnaces and Open Hearth Plant.

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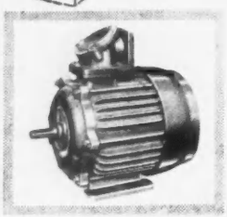
Think of a motor car running a thousand miles every day, year in and year out. Think of the revs. Well, very many EPE users expect and get revs. of this magnitude from their electric motors, taking it for granted that if they are EPE they will stand up to the usage. That is just as it should be. We like to think our motors are fitted and forgotten. If you are not already using EPE motors, we shall be happy to send you details.



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HIGEARS

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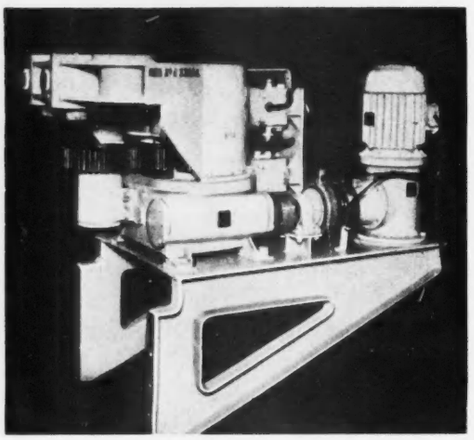

In addition to our standard ranges we are technically equipped to design and manufacture special gear units. This illustration shows one of our special designs we supplied for the Dounreay Fast Breeder Experimental Reactor

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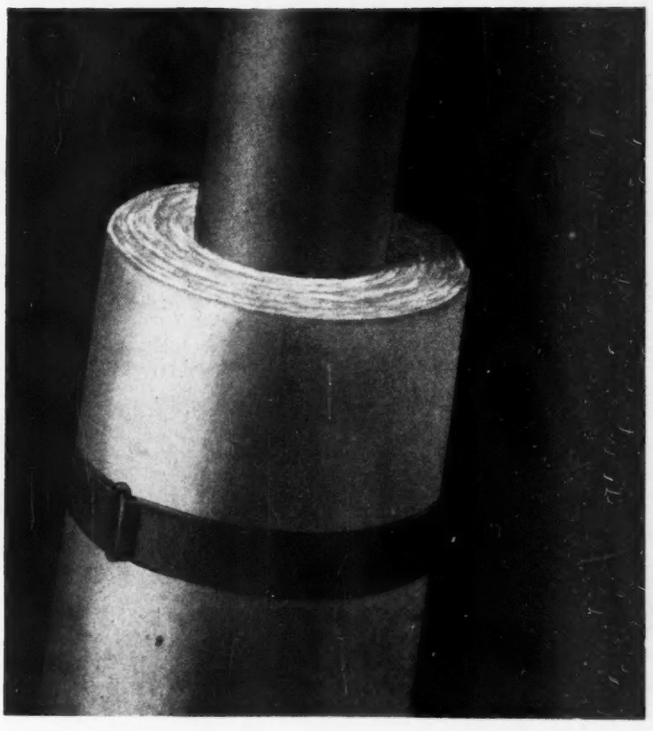
"I WAS A WASTER!"

– *STEAM PIPE CONFESSES*

"I am a four-inch bore pipe. I work in a factory. It is my job to carry steam at 450°F. from generator to the plant. But I was a waster, a fuel waster, a *very* fuellish waster indeed!

I used to work naked as the day I was drawn. Of course I wasted heat—and therefore fuel—but who cared? Then one day, a bright spark from Fibreglass told the Manager that I was wasting nearly one ton of coal a year through each foot of my length.

I felt naked—and ashamed. Quickly they had me wrapped in a Fibreglass rigid section $1\frac{3}{4}$" thick. Now, this is saving $18\frac{1}{2}$ cwts. of each ton I used to waste. My conscience is clear; but if pride is a sin, I'd better look out. Because I *am* proud of my slim figure, my neat nesting and my light-weight on hangers."



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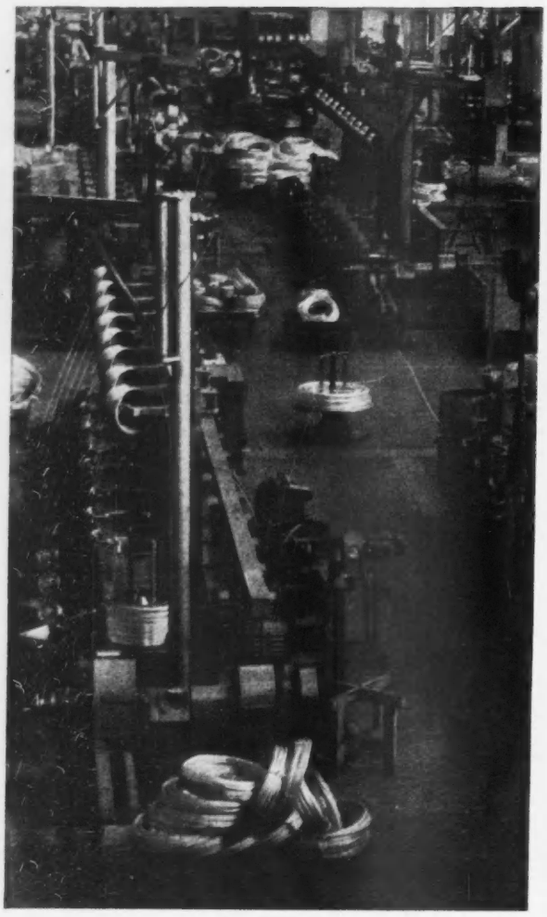
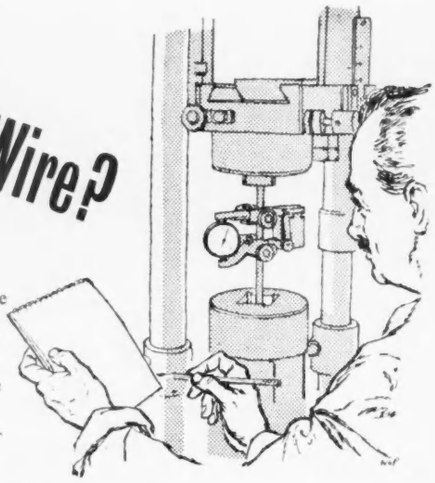


Why Aluminium Wire?



Light weight, durability and an attractive appearance are three of the reasons why aluminium and aluminium alloy wire are so widely used by many industries today.

AWCO's policy of careful laboratory control and inspection at all stages of manufacture ensures that the wire reaches the customer in the best possible condition for the work it has to do.

AWCO make dependable aluminium and aluminium alloy wire.

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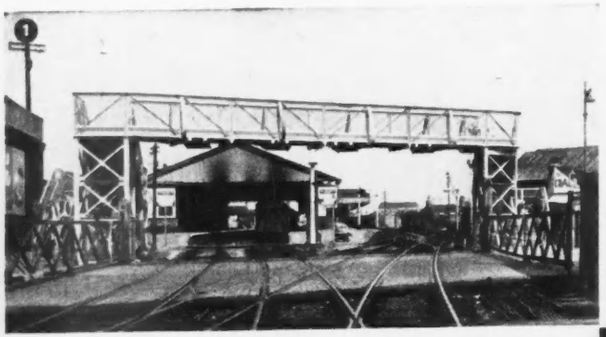
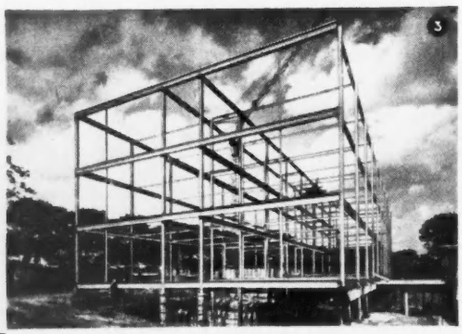
AP53

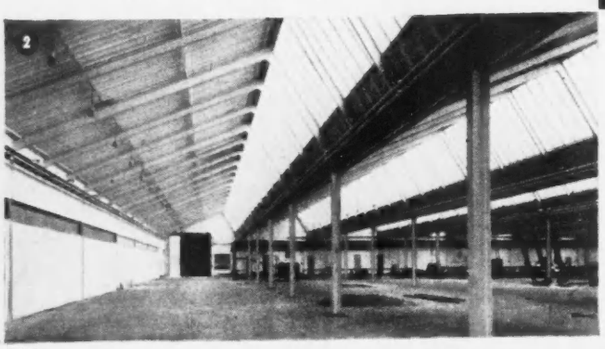
STRUCTURAL STEELWORK

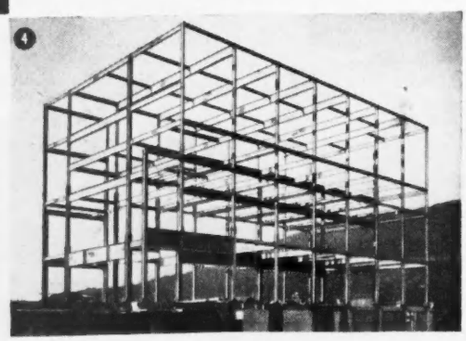
BY AUSTINS





1. Footbridge for Level Crossing in Grimsby.
2. Interior view of factory for Messrs. Brook Motors Ltd., Barnsley.
3. Sowerby Bridge Secondary School.
4. Control Room, Services and Welfare Block, Elland Power Station.





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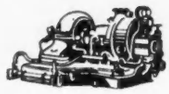

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Over 50 years' experience.
Scores in hand—thousands in service.

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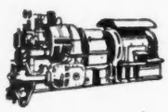

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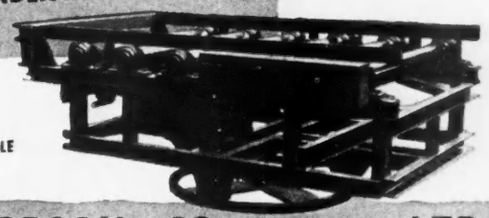

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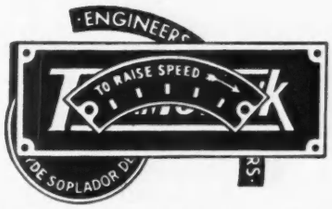

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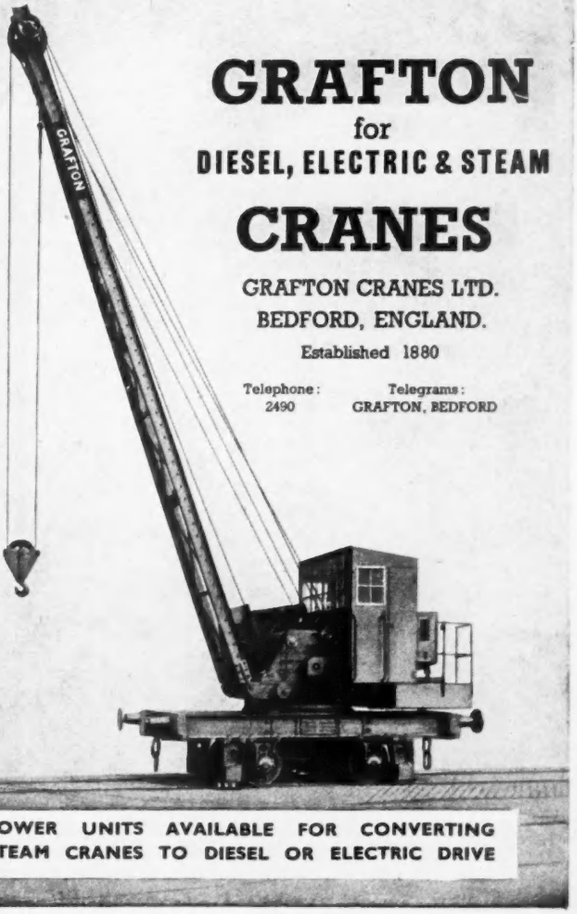
PAISLEY - SCOTLAND



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CRANES

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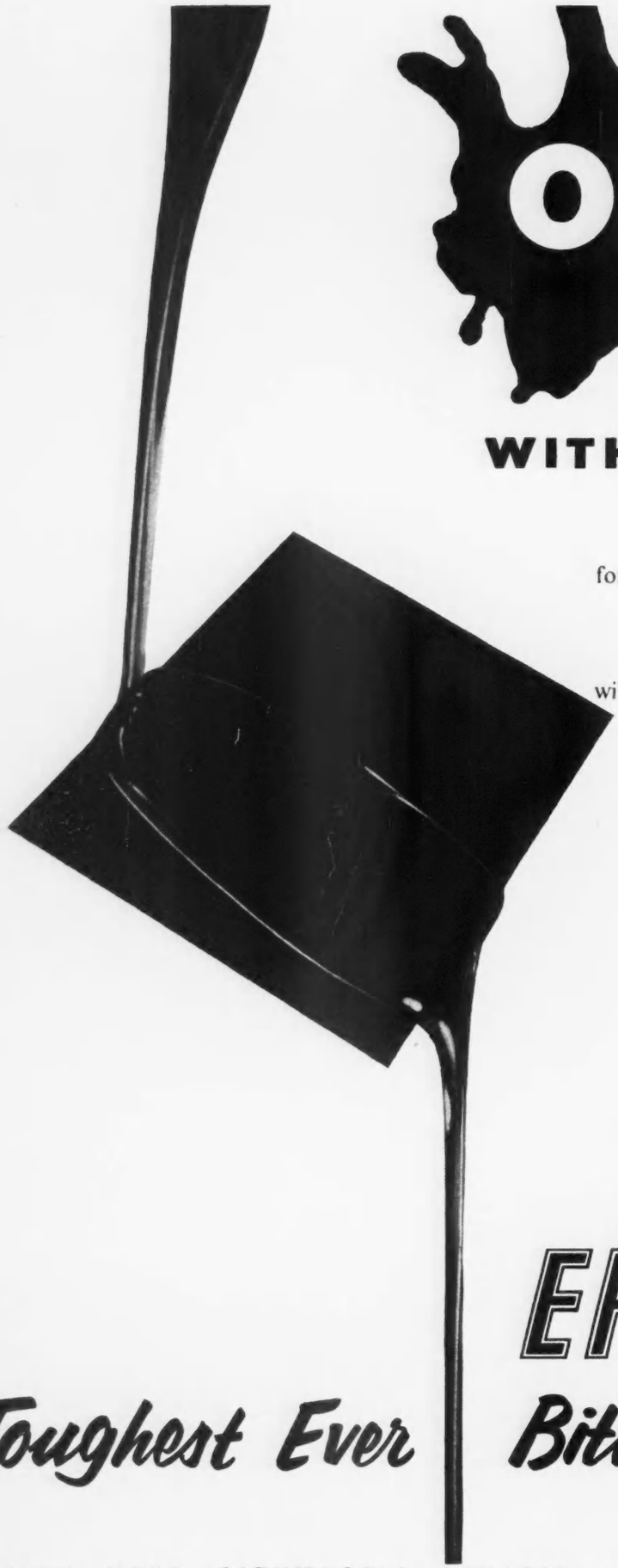

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Resistance to oil is only one of EPIMASTIC'S many virtues. Why not write for Technical Leaflet No. 20 for the full story.

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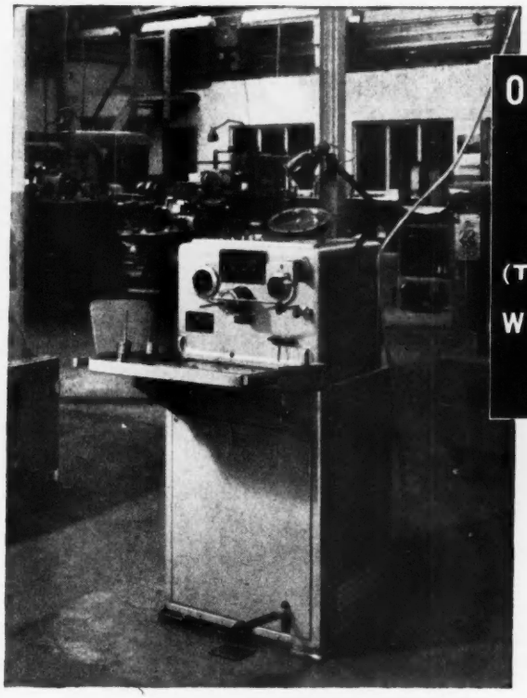

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Eagre's skilful planning and practical experience on railway preparation, from earthworks to the finished job, ensures that your scheme can be well and economically laid.

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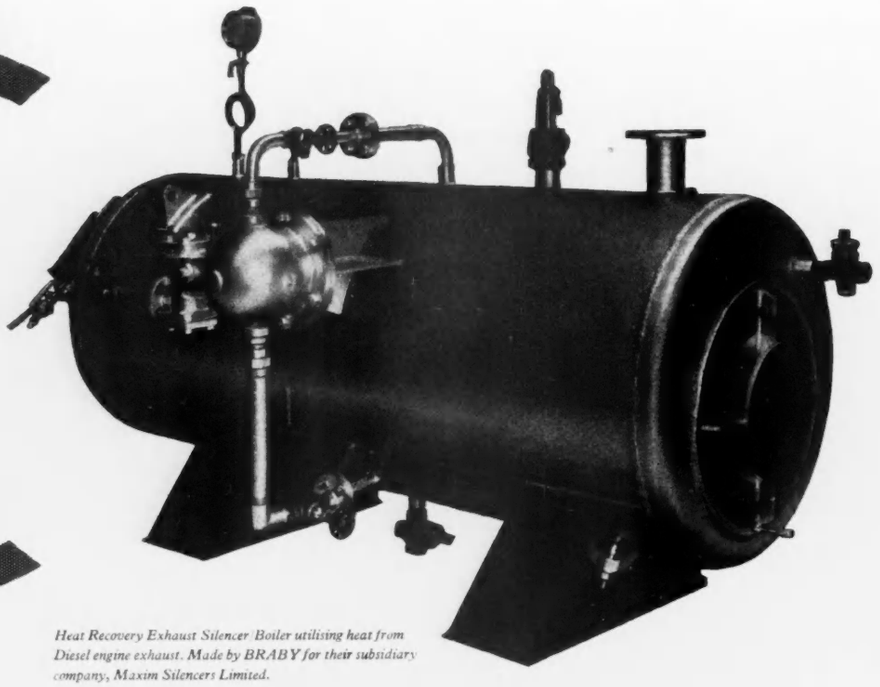
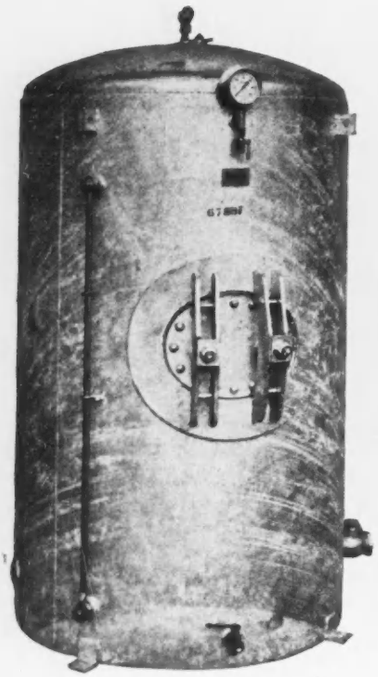


Heat Recovery Exhaust Silencer Boiler utilising heat from Diesel engine exhaust. Made by BRABY for their subsidiary company, Maxim Silencers Limited.



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Mild Steel Plate Cyclones and Ducting supplied and erected at large Cattle Feed Mill in London.

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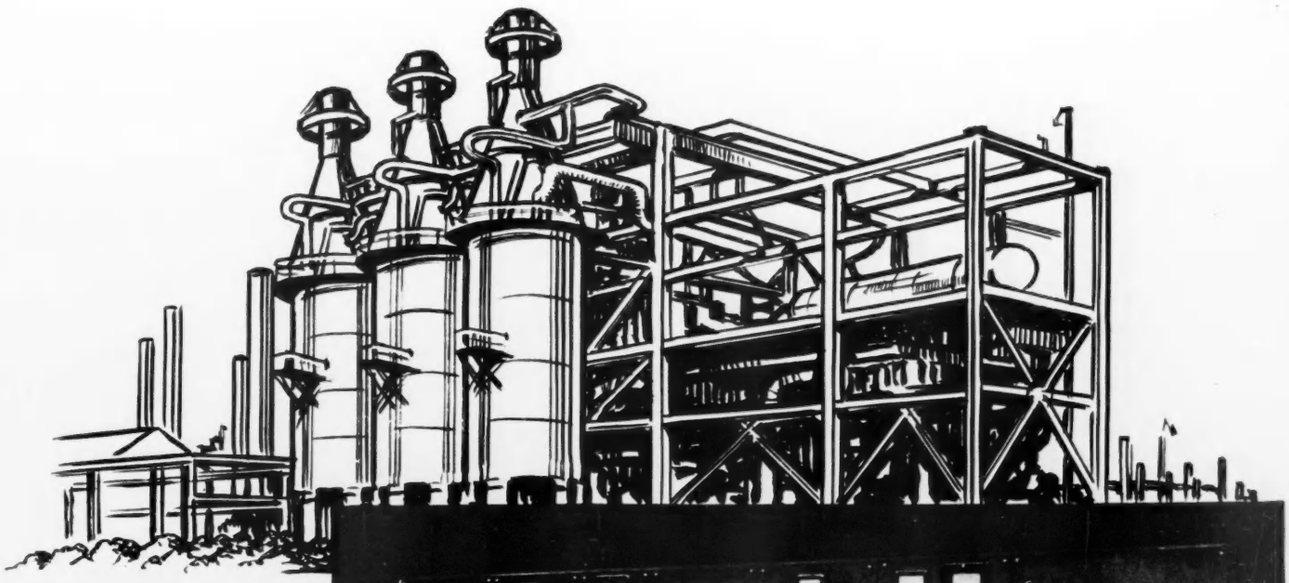
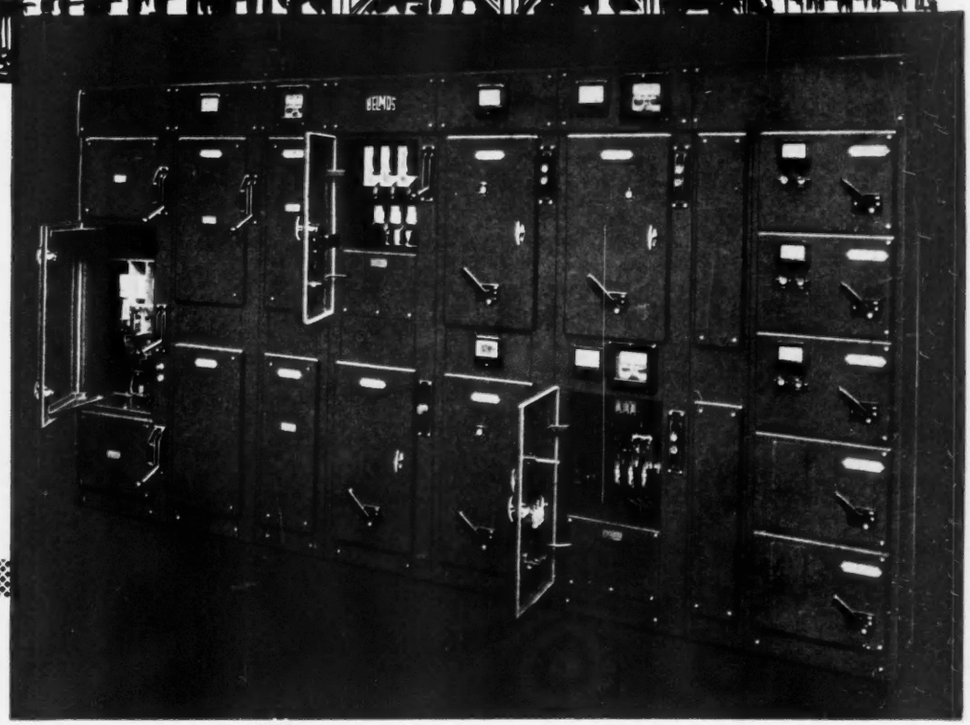
API39





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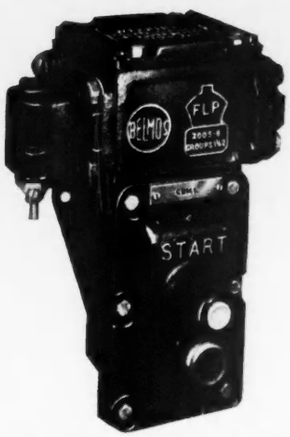

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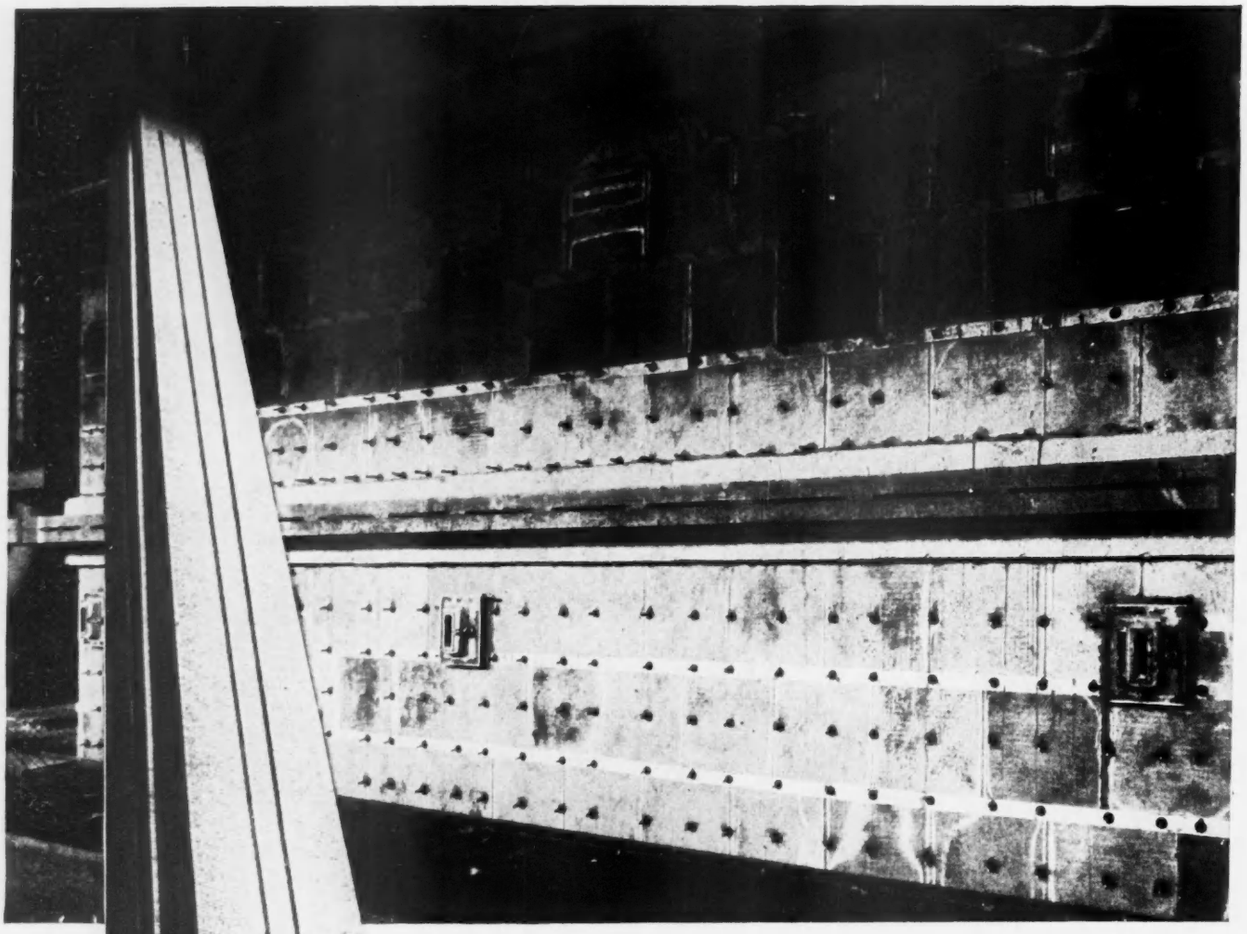

refractory and insulating construction

R. B. HILTON LTD, while fully maintaining their interest in well tried and traditional methods, are actively to the fore in developing new systems to suit special conditions and demands.

The illustration shows the refractory cladding applied to a very large power station boiler. In this instance prefabrication was extensively used. And the photograph shows the installation ready to receive the low temperature insulation. This particular system, developed and patented by the R.B.H. GROUP, is now used very widely on modern power station boilers.

R. B. HILTON'S activities range from the refractory and insulation work involved in the largest national and industrial undertakings down to the repair of the smallest self-contained boiler.

A special department deals with chimney construction and maintenance.

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Brick stack for Joseph Lucas Limited, Birmingham

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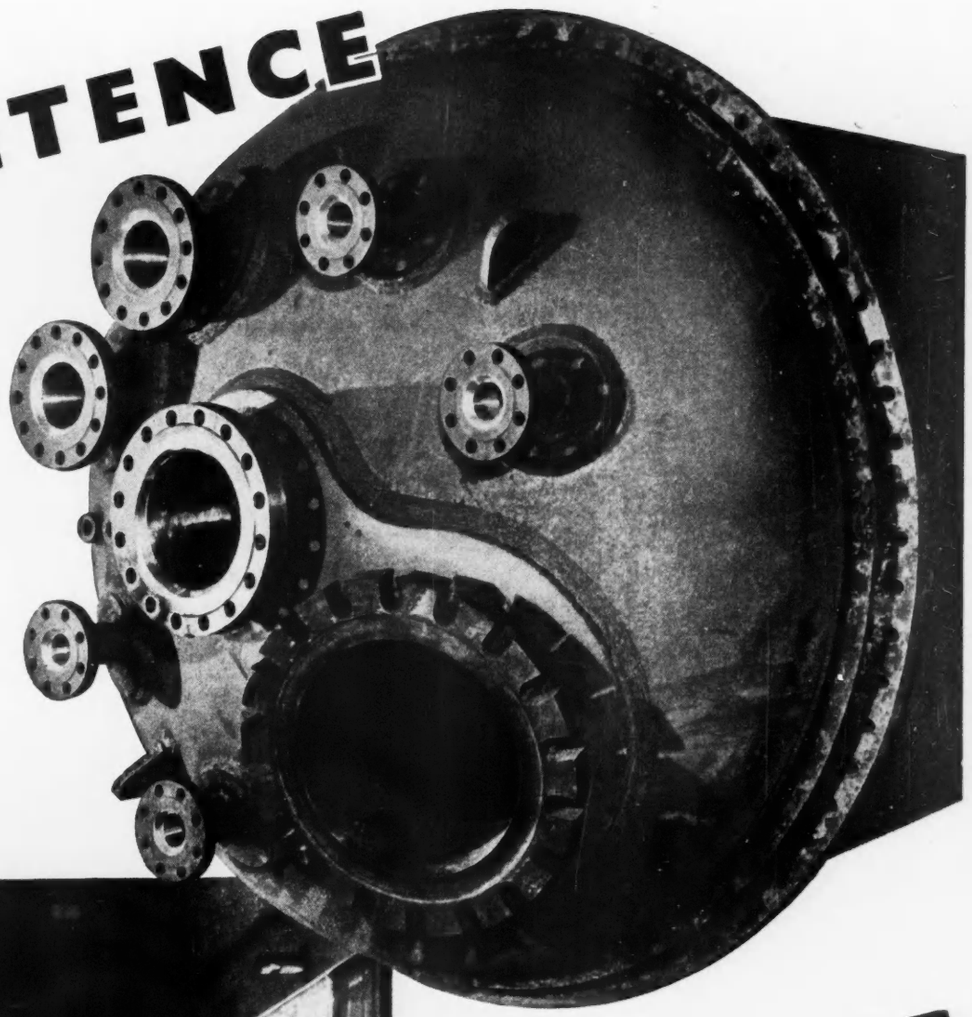
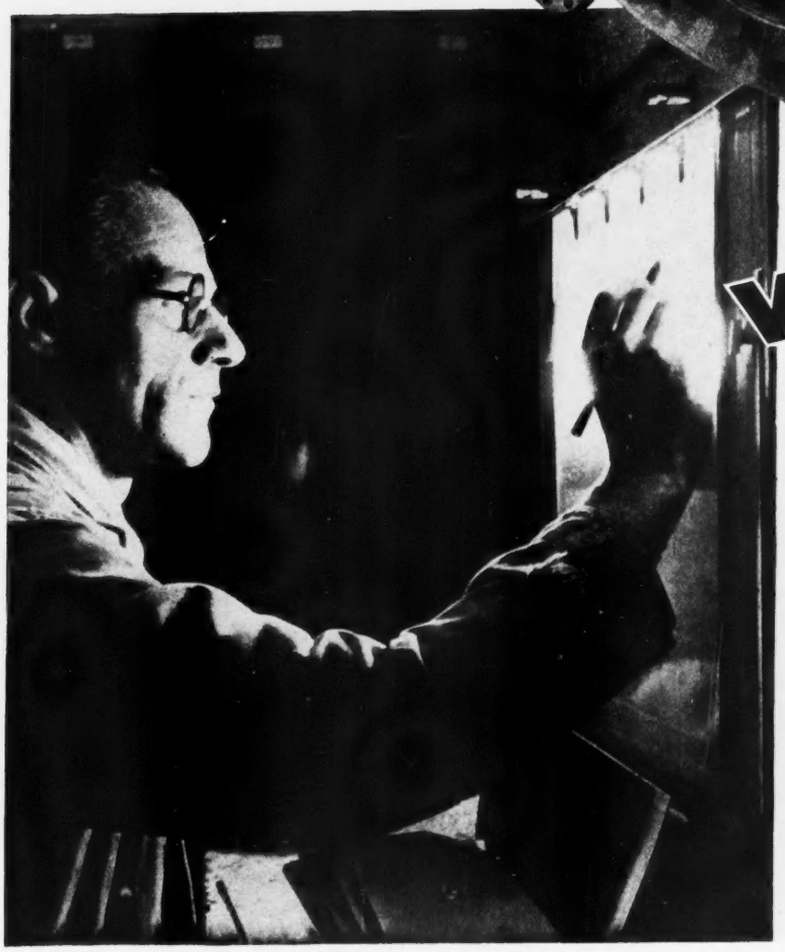
COMPETENCE



Head of a 6ft. dia. Autoclave, spun on the Harvey "Rotar-press" from a stainless steel disc 1⅝in. thick. Designed for a working pressure of 500 lbs./sq. in.



VIGILANCE

KEYNOTES OF

Harvey

FABRICATION

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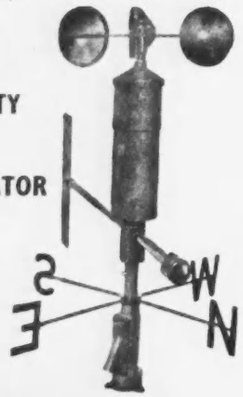
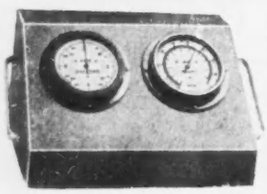
for mains operation combined with

WIND VELOCITY CUP GENERATOR



NO brushes or rubbing contacts

Swift ★ COMET Sure



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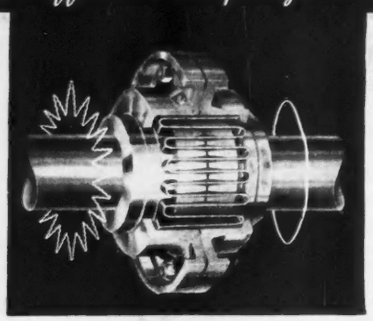

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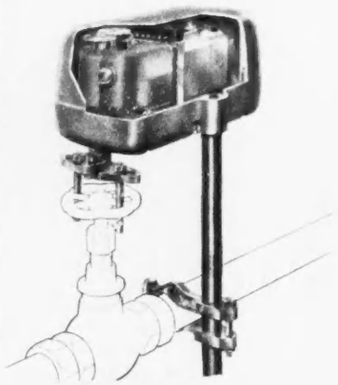

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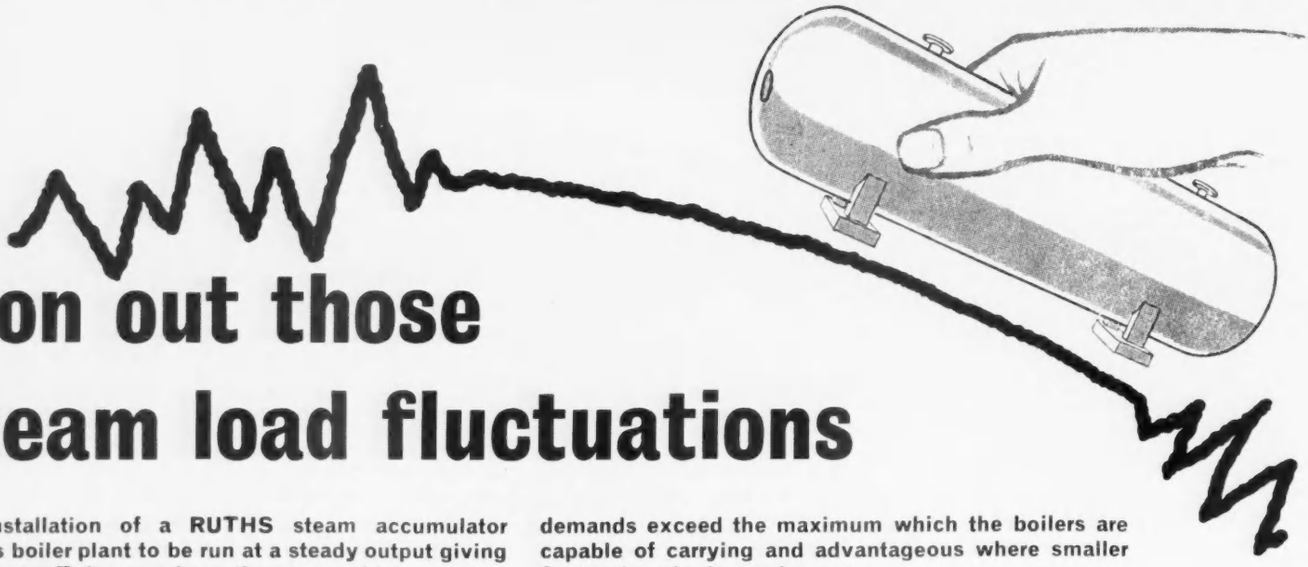

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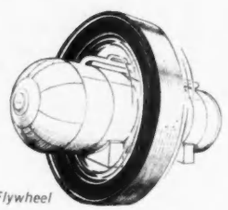

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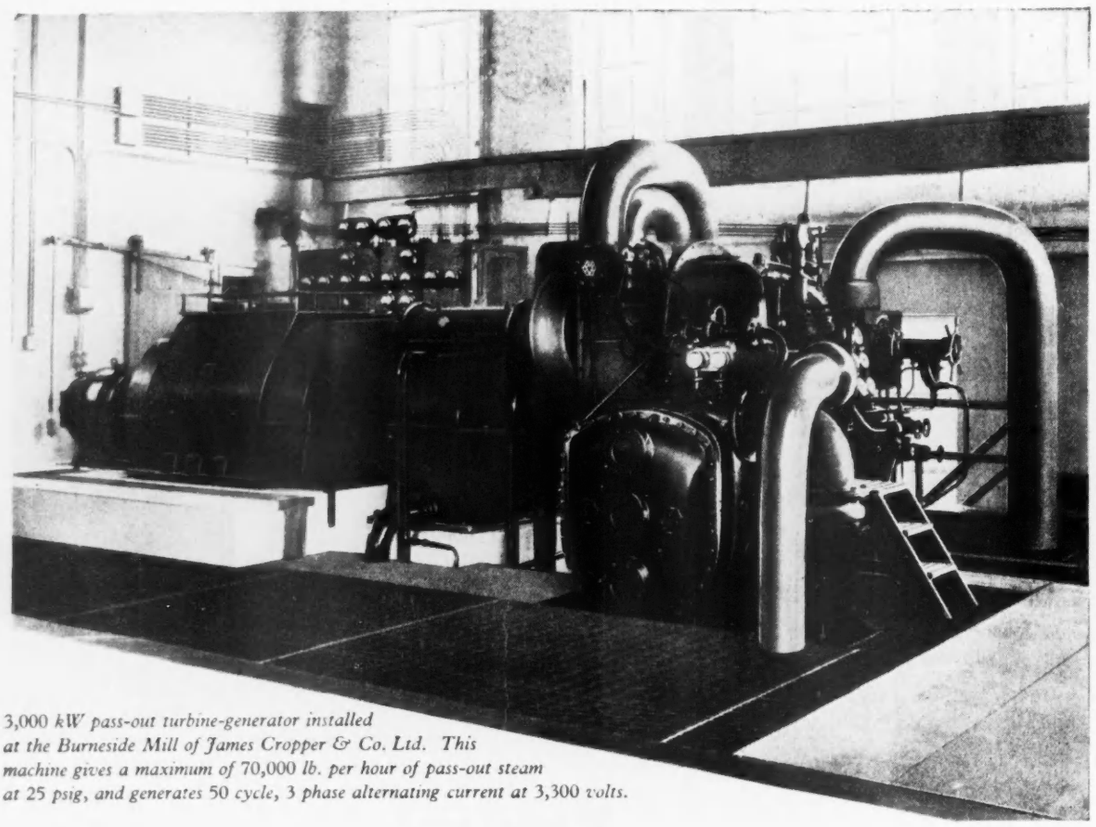

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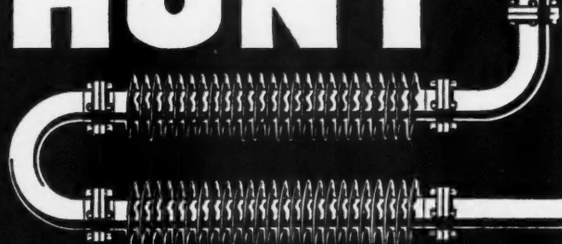

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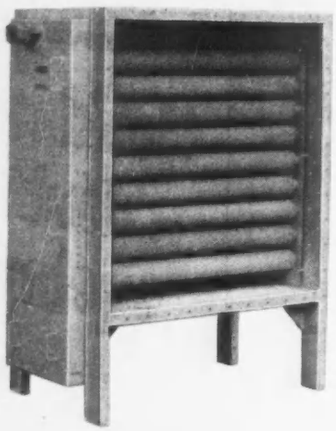

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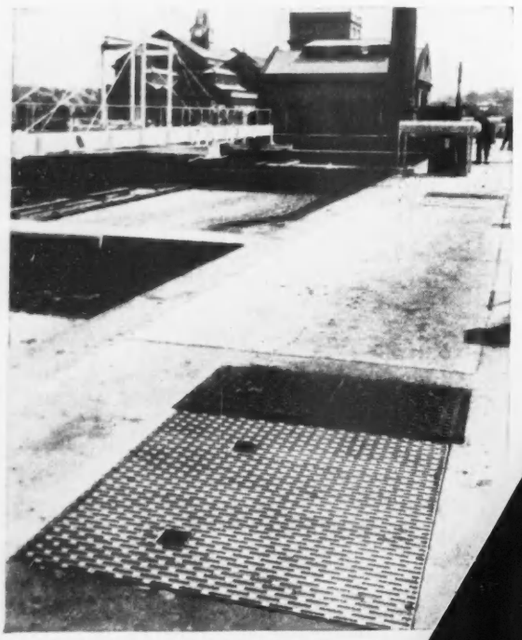

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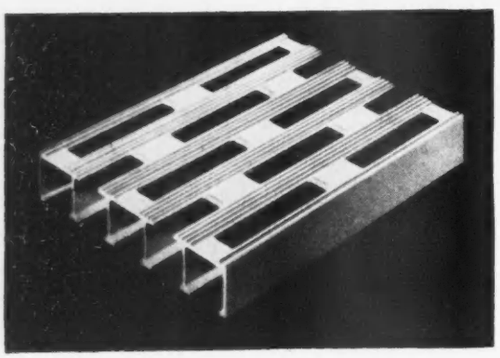

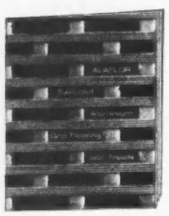

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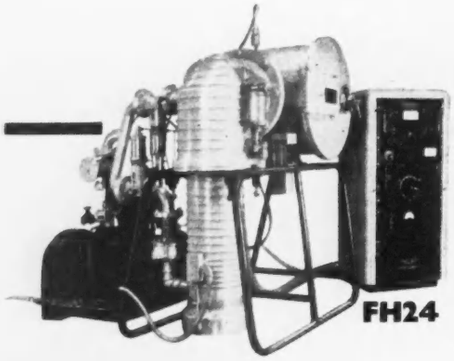

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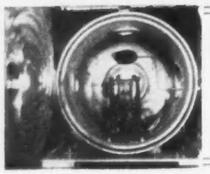

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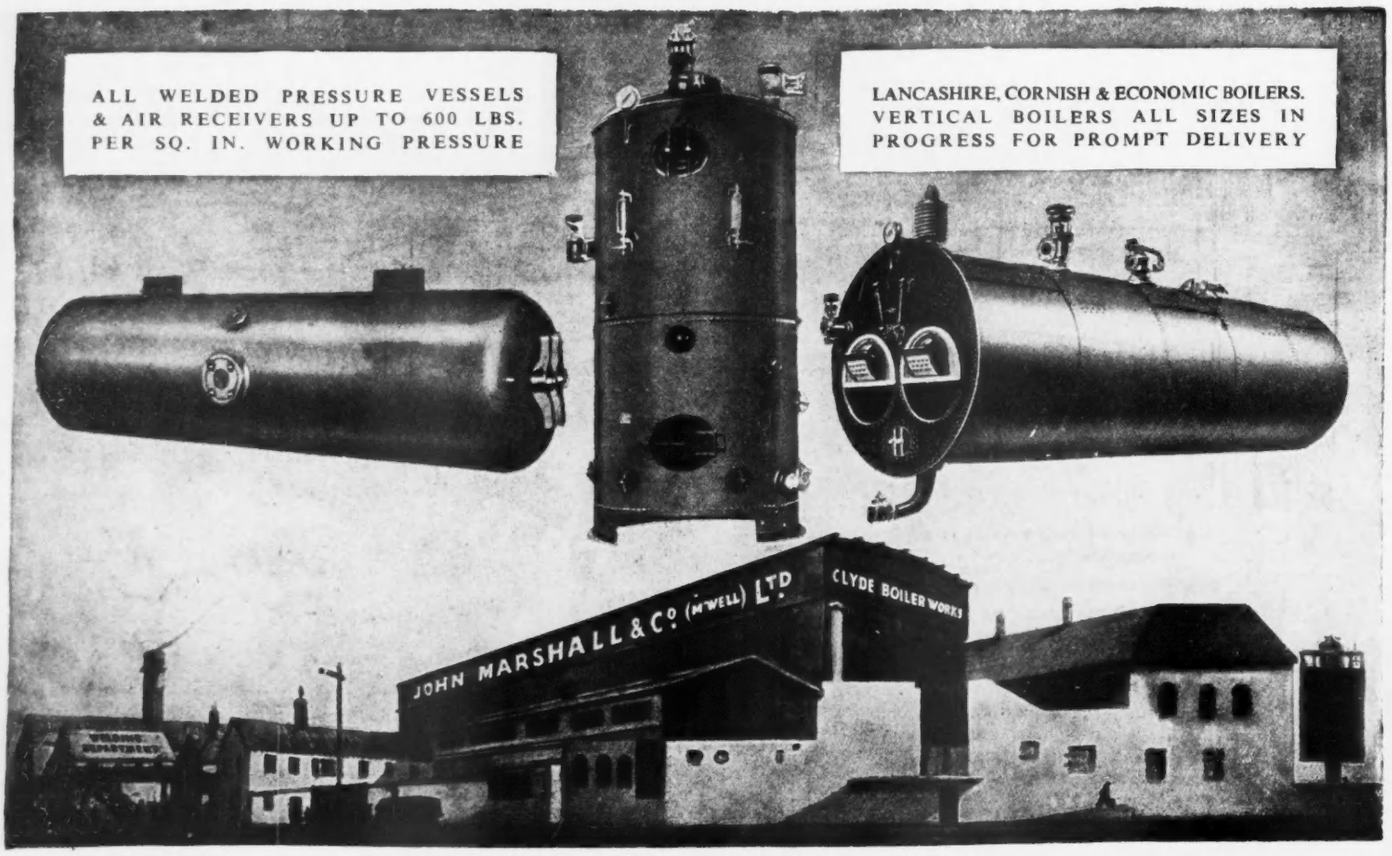
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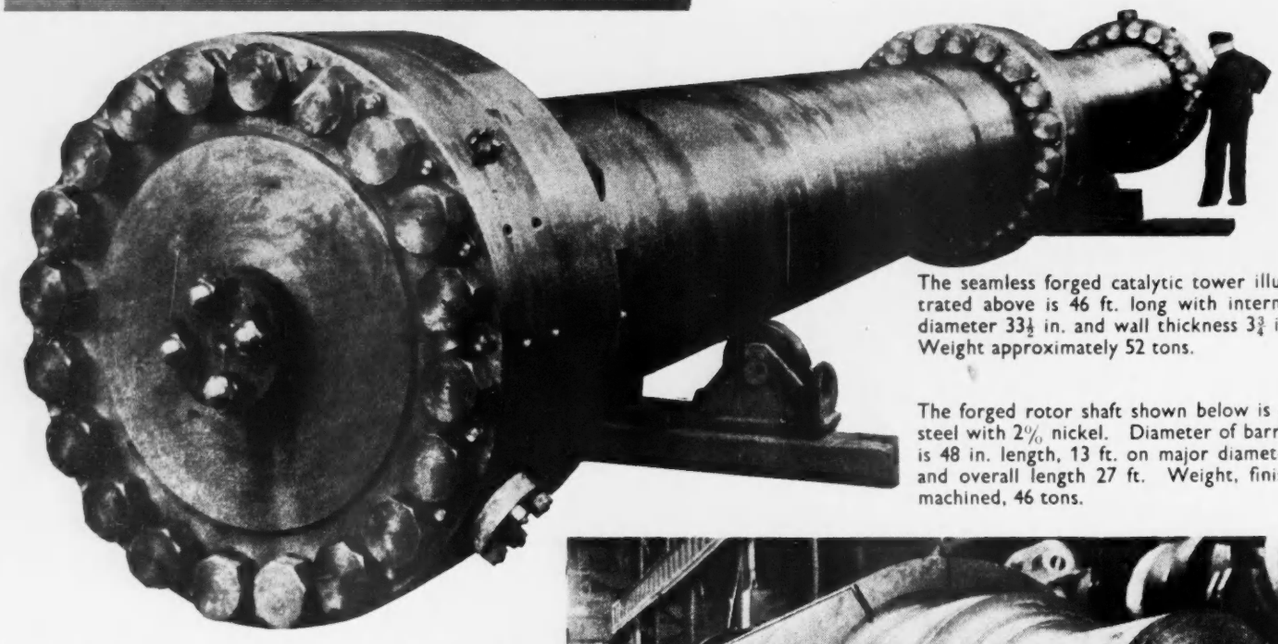
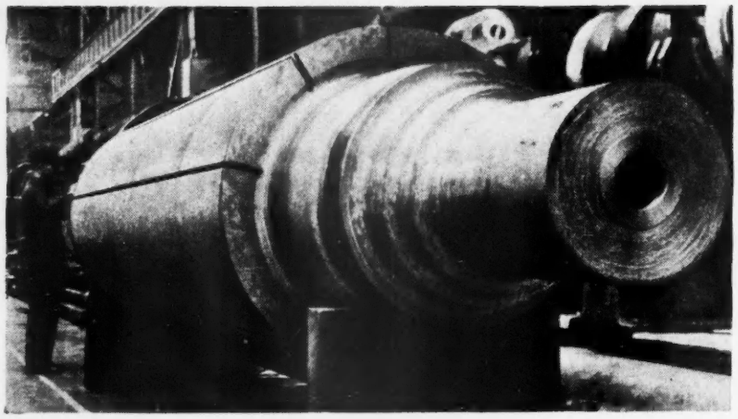


The seamless forged catalytic tower illustrated above is 46 ft. long with internal diameter 33½ in. and wall thickness 3¾ in. Weight approximately 52 tons.

The forged rotor shaft shown below is of steel with 2% nickel. Diameter of barrel is 48 in. length, 13 ft. on major diameter and overall length 27 ft. Weight, finish machined, 46 tons.



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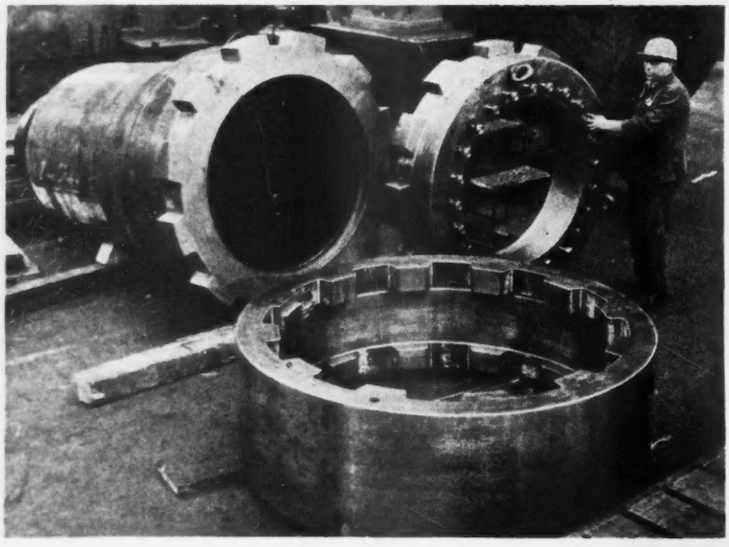

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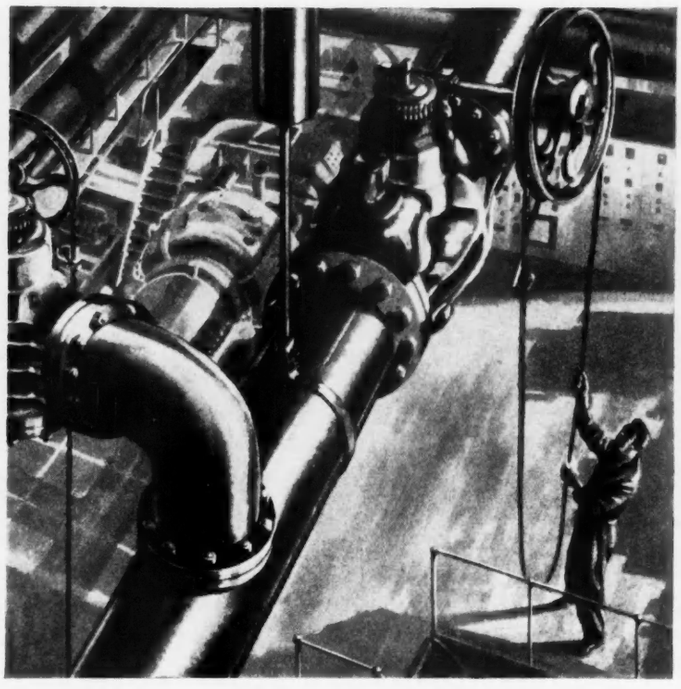

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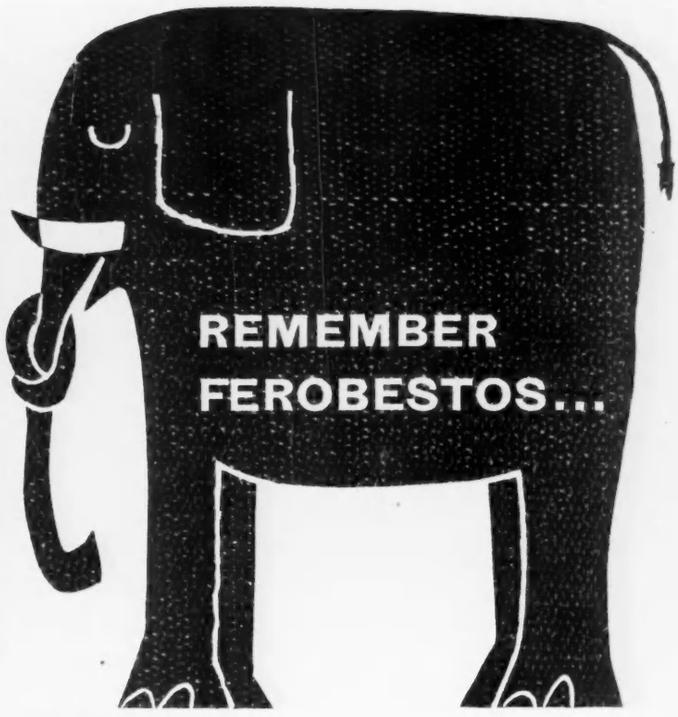

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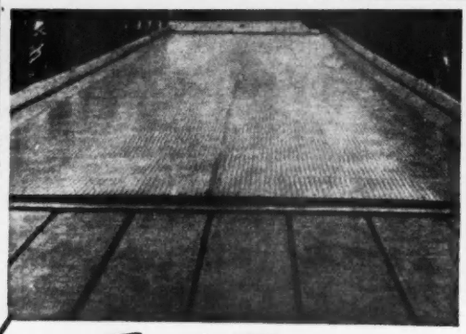

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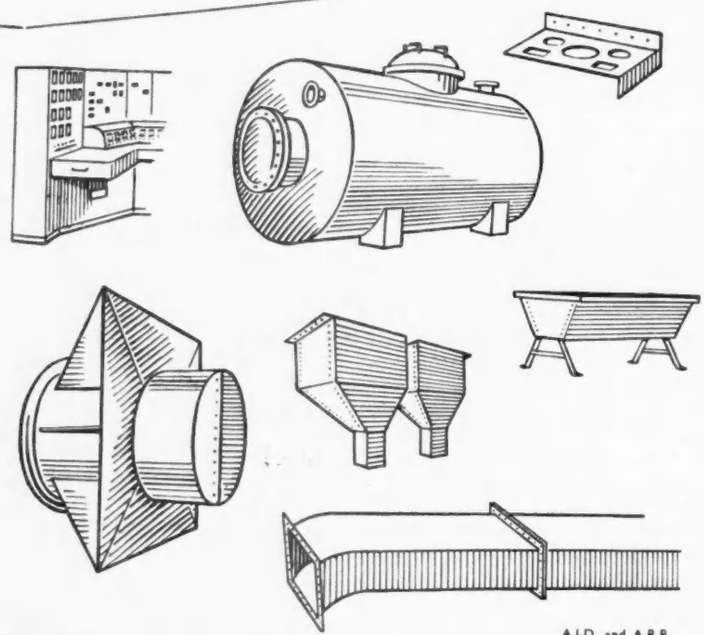

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

BRADFORD INSTITUTE OF TECHNOLOGY

Principal: E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR LECTURER

Applications are invited for appointment of SENIOR LECTURER in the Department of Mechanical Engineering. Applicants should be Graduates, and Corporate Membership of a professional Institution is desirable.

The salary scale, for men, in accordance with the Burnham Technical Award, is from £1350 to £1550 per annum.

Previous industrial or research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Institute of Technology, Bradford, 7.

W. H. LEATHEM,
Clerk to the Governors.

E9662

ROYAL TECHNICAL COLLEGE, SALFORD

READERS IN MECHANICAL ENGINEERING

Applications are invited for one or more vacancies of READER in the DEPARTMENT OF MECHANICAL ENGINEERING. The person or persons appointed will be primarily concerned with leading research in appropriate fields of mechanical engineering, and may also lead to other advanced studies. Applicants should have records of proven research ability in some field of mechanical engineering. No one field of research experience is required and applications from those with an interest in fundamental research into manufacturing processes or machine tools would also be welcomed. Teaching experience, though a valuable additional qualification, is not essential. The Department has a substantial number of students working for the Diploma in Technology, and research facilities are being rapidly expanded.

Salary will be in accordance with the Burnham Technical Scale for Readers, viz. £1500–£1800.

Forms of application, together with further particulars, may be obtained from the Registrar, Royal Technical College, Salford, 5, to whom they should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors.

E9705

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR RESEARCH ASSISTANT

Honours Graduates in Engineering or Physics interested in "Problems related to strength of materials" are invited to apply for appointment as SENIOR RESEARCH ASSISTANT (salary £900 to £1300, with superannuation and family allowance), or RESEARCH ASSISTANT (salary £600 to £900) in the above Department. Initial salary according to qualifications and experience.

Information concerning the Department and research in progress, conditions of appointment, and form of application, which should be returned by 14th February, 1959, from the Registrar. E9690

UNIVERSITY OF MANCHESTER

LECTURER

Applications are invited for the joint post of LECTURER IN THE DEPARTMENTS OF ENGINEERING and of the MECHANICS OF FLUIDS, who will be responsible for the teaching of Aircraft Structures and Aero-Elasticity. Facilities for research will be made available in either the Engineering Department or in the Fluid Motion Laboratory at Barton, which ever is appropriate. Salary scale: £900 to £1650 per annum, initial salary according to qualifications and experience. Membership of F.S.S.U. and Children's Allowance Scheme.

Applications should be sent not later than January 31st, 1959, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of applications may be obtained. E9541

BUCKINGHAMSHIRE EDUCATION COMMITTEE

HIGH WYCOMBE COLLEGE OF FURTHER EDUCATION

(Principal: W. J. DAVIES, J.P., B.Sc.)

GRADE B ASSISTANT

Required, as soon as possible, GRADE B ASSISTANT with Graduate or equivalent qualifications. Industrial and/or teaching experience in heavy current subjects desirable. The successful candidate will be required to teach relevant subjects to O.N.C. level and some work to H.N.C. level could be arranged. A candidate who could also offer electrical installation work would be considered.

Salary will be in accordance with the appropriate Burnham Report, i.e. £650/£1025 for a man, plus allowances for appropriate qualifications and previous approved experience.

Forms of application may be obtained from the Principal at Queen Alexandra Road, High Wycombe, to whom completed application forms should be returned as soon as possible. E9681

UNIVERSITY COLLEGE OF SWANSEA

ENGINEERING CLERK OF WORKS

Appointment of ENGINEERING CLERK OF WORKS.

RESIDENT ENGINEER required by the University College of Swansea, to supervise and control a number of Mechanical and Electrical Engineering Sub-Contracts in connection with building development at the College. Candidates must be not less than 35 years of age and possess technical qualifications up to National Certificate standard, Mechanical and/or Electrical, or be Graduate or Associate Members of the Institution of Electrical Engineers, or I.H.V.E. Preference will be given to applicants who have had some design experience, whether in heating and ventilation or in electrical installations, and who have had previous experience in supervision on site of Engineering works. The inclusive salary will be £1000–£1250 per annum, according to experience.

Applications, in writing, should be made to the Architects, Sir Percy Thomas and Son, 10, Cathedral Road, Cardiff, giving full particulars of age, qualifications and experience. Closing date for applications is February 5, 1959. E9544

THURROCK URBAN DISTRICT COUNCIL

ENGINEER AND SURVEYOR'S DEPARTMENT

ENGINEERING ASSISTANT

Thurrock Urban District Council (Engineer and Surveyor's Department) require ENGINEERING ASSISTANT. Salary within A.P.T. I/II, i.e. £575–£845 p.a. Candidates should have completed their training in a Municipal or Civil Engineer's Office, and have had some subsequent experience. Appointment pensionable. Applications, stating age, qualifications and experience, and quoting three referees, to Clerk of the Council, Council Offices, Grays, by 10th February, 1959. Canvassing disqualifies. Relationship with members or senior officers of the Council must be disclosed. E9682

BRITISH WATERWAYS

WATFORD

ENGINEER (MECHANICAL AND ELECTRICAL)

British Waterways invite applications from qualified Engineers (preferably A.M.I.Mech.E.) for post of ENGINEER (MECHANICAL AND ELECTRICAL) in their office at Watford. Salary range of £1315–£1590 p.a., with superannuation scheme and certain railway privilege travel facilities. The person appointed will be responsible under the Divisional Engineer for the maintenance of plant, equipment and craft and for the preparation of drawings and specifications for all new plant and craft which may be wanted. Practical experience and administrative ability to control repair yard and workshops essential.

—Applications to Staff and Establishment Officer, British Waterways, 163, Euston Road, London, N.W.1, by 30th January, 1959. E9687

COMMONWEALTH OF AUSTRALIA

SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY

VACANCIES FOR ENGINEERS

Applications are invited for appointment as CIVIL, ELECTRICAL and MECHANICAL ENGINEERS for all phases of civil engineering and hydro-electric power station construction and associated installations.

Applicants should possess qualifications complying with the examination requirements for Graduate Membership of the Institutions of Civil, Electrical or Mechanical Engineers (London), or the Institution of Engineers, Australia, or should be final year engineering students of a recognised University or Technical College.

Appointments will be to the following grades of Engineer, grade and salary being determined by qualifications and experience:—

Engineer, Grade I, £A1056–£A1416; Engineer, Grade II, £A1416–£A1506; Engineer, Grade III, £A1506–£A1686.

All salaries are in Australian currency and will commence from the date of entry on duty.

All positions will be in the Snowy Mountains Area located in south-eastern New South Wales, with headquarters at Cooma, some 70 miles south of Canberra. Housing on a rental basis will be available for married appointees and hostel accommodation will be provided for single men.

Subject to certain conditions the Authority will consider payment of first-class steamship fares to Australia of successful applicants and, if married, those of their wives, and children under 16 years. Otherwise arrangements will be made for assisted passages to Australia.

Applications, accompanied by a recent photograph and copies only of testimonials, and giving full details of qualifications and experience, should be addressed to Snowy Mountains Hydro-Electric Authority, Australia House, Strand, London, W.C.2.

Closing date for applications is 14th February, 1959. E9680

SHENLEY HOSPITAL

SHENLEY, ST. ALBANS, HERTS

SUPERINTENDENT ENGINEER

Applications are invited from suitable qualified engineers for the appointment of SUPERINTENDENT ENGINEER.

The Officer appointed will be responsible for the satisfactory operation, maintenance and co-ordination of all the engineering services, both mechanical and electrical, of this Hospital of over 2000 beds, and for the efficient control of the engineering staff, plant, services and equipment.

Applicants should have completed an apprenticeship in mechanical engineering and obtained appropriate qualifications by examination.

The post is permanent and superannuable and carries a salary on the scale £1030–£1185 per annum.

The Hospital is situated in a country district within easy reach of London. A modern detached house on the estate will become available for the officer appointed.

Forms of application returnable not later than the 9th February may be obtained from the Group Secretary. E9715

WAR DEPARTMENT

WILTS

CLERK OF WORKS (MECHANICAL)

CLERK OF WORKS (MECHANICAL) required by War Department in Wilts. Applicants must be of British parentage and have O.N.C. in Mechanical Engineering or equivalent, and five years apprenticeship or equivalent with engineering concern.

Experience: Further three years with an engineering firm, or three years as supervisor of labour, chargehand or technical officer in engineering industry.

Completion of course at S.M.E. is equivalent qualification.

Salary according to age, qualifications, and experience on range of £655 (at age 26) to £829 per annum.

Apply: Chief Engineer, Salisbury Plain District, Bulford Camp, Wiltshire. E9614

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service requires SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS for establishments in London area, Baldock, Portsmouth, Portland, Poole and Rosyth. Main requirements are for PHYSICISTS, MECHANICAL ENGINEERS, ELECTRONIC ENGINEERS and MATHEMATICIANS in areas specified. The following particular vacancies also exist:—Mathematician: for applied research of basic nature and stability of underwater vehicles; knowledge of theoretical hydrodynamics and theory of control systems an advantage; London area. Mechanical Engineer: with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in a particular field of applied hydrodynamics; experience in modern methods of design and research on axial-flow compressors, turbines or pumps an advantage; London area. Mechanical Engineers: for design and development of underwater devices; Portland area. Physical Chemist: with specialised knowledge of rubber technology; Poole area. Chemists: Physical and Inorganic; Poole, Baldock and London areas. Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees or equivalent high professional attainments. S.S.O.s must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men): S.S.O., £1190–£1410; S.O., £635–£1110 (London)—somewhat lower in provinces. Appointments are unestablished (with F.S.S.U. benefits), but opportunities may occur for these between ages of 21 and 32 to compete for established posts.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.500/8A). E9615

TRENT RIVER BOARD

TAMWORTH, STAFFS

APPOINTMENT OF
ASSISTANT ENGINEER

Applications are invited for the appointment of an ASSISTANT ENGINEER at the Board's Divisional Office at Tamworth, Staffs. The duties of the post will include the design and execution of land drainage works within the southern part of the Board's area.

The successful applicant (if a Graduate Engineer with more than five years' experience—including a period spent on theoretical training) will be appointed at a salary within the Special Grade for Engineering and Surveying Assistants (£750–£1030 per annum) of the National Scheme of Conditions of Service for Local Government Officers. With lesser qualifications, the successful applicant will be appointed within A.P.T. Grades I–II (£575–£845 per annum). The appointment will be subject to the Local Government Superannuation Acts.

A car allowance on the "essential user" scale will be payable, and it is the Board's practice, in suitable cases, to operate the Assisted Car Purchase Scheme.

Applications, with full particulars, including copies of testimonials or the names of at least two referees, must reach the Engineer to the Board, P.O. Box No. 74, 206, Derby Road, Nottingham, not later than 14th February, 1959.

JOHN HIRST,
Clerk of the Board.

E9688

PORT OF BRISTOL AUTHORITY

CHIEF DRAUGHTSMAN

Application invited for above post which is in charge of a small Drawing Office covering whole scope of Engineer's Department.

Salary Grade A.P.T.V £1175 by £50 p.a. to £1325. Commencing salary within this range will depend upon age, qualifications and experience. Appointments subject to medical examination and six months' probationary period. Post pensionable in accordance with provisions of Local Government Superannuation Act, 1953.

Applicants must disclose whether they are related to a member or senior officer of Bristol Corporation. Canvassing disqualifies.

Applications stating age, qualifications, experience, &c., and enclosing, if possible, copies of recent testimonials, in envelope endorsed "Chief Draughtsman" to Engineer-in-Chief, Port of Bristol Authority, Avonmouth Docks, Bristol, by 30th January. E9714

Classified Advts. continued on page 112

PUBLIC APPOINTMENTS

GHANA PUBLIC SERVICE COMMISSION

PUBLIC WORKS DEPARTMENT

APPOINTMENTS

Applications are invited for the following vacancies in the Public Works Department :—

MECHANICAL ENGINEERS (ROADS) : responsible for the installation and maintenance of mobile plant, equipment and vehicles, general supervision and administrative work in connection with the Mechanical Branch of the Department, including control of finances and overall control and training of subordinate staff. Candidates must either (a) hold a B.Sc. (Eng.), or other recognised Degree giving exemption from Parts I and II of the examination of the Institution of Mechanical Engineers, and have had 2 years' post-graduate practical experience, or (b) being not less than 23 years of age have passed Parts I and II of the Institution's examination. Salary range £1080–£2080 p.a.

EXECUTIVE ENGINEERS (ROADS) : for planning, design and construction of trunk roads and the realignment and reconstruction of existing roads. Candidates must hold a University Degree in Civil Engineering or be A.M.I.C.E. with two years' experience in the planning, design and construction of trunk roads, bridges and ancillary roads or Corporate Members of I.C.E. or Municipal Engineers with experience in road construction. Salary range £1080–£2080 p.a.

Appointments on contract for two to three tours, each of 18–24 months' duration. Gratuity at rate of £12 10s. for each completed month of residential service payable on completion of contract. Outfit allowance £30–£60 on first appointment. Free first-class passages for officer, wife and up to 3 children under 18 years, and, in addition, an education allowance for children when not resident in Ghana of £100 a child for up to 3 children under 18 years. Generous home leave on full pay. Income tax at low local rates.

For further particulars and application form write, stating age, qualifications and experience, to The Director of Recruitment, Ghana High Commissioner's Office, 13, Belgrave Square, London, S.W.1.

E9678

CONSERVATORS OF THE RIVER THAMES

OXFORD AND SUNBURY-ON-THAMES

TWO ASSISTANT DIVISIONAL ENGINEERS

Applications are invited for the appointment of TWO ASSISTANT DIVISIONAL ENGINEERS at Oxford and Sunbury-on-Thames. Salary scale £725 at age 23, to £1025 at age 32.

Extensive practical experience is not required, and the posts are suitable for young men starting their professional careers. Candidates must have passed Parts 1 and 2 of the Institution of Civil Engineers examinations or hold qualifications exempting them. Candidates will be employed in the field in charge of direct labour works and occasional contract work.—Further details from Chief Engineer, Thames Conservancy, De Bohun Road, Reading, Berks.

E9673

MERSEY RIVER BOARD

ENGINEER'S DEPARTMENT

ASSISTANT ENGINEER

Applications are invited for the appointment of ASSISTANT ENGINEER at the Board's offices at Great Sankey, Warrington, Lancashire.

The salary for this appointment will be in accordance with the National Joint Council for Local Authorities Scheme of Conditions of Service ranging from £575 to £1030. The appointment is subject to the Local Government Superannuation Acts, 1937 and 1953, and to the passing of a Medical Examination. Candidates should have passed the final examinations Part I and Part II of the Institution of Civil Engineers or hold a University Degree exempting them therefrom.

Applications stating age, education, qualifications and experience together with the names and address of two persons to whom reference may be made should be addressed to J. T. Firth, B.Eng., M.I.C.E., Engineer to the Board, at the address given below and should be received not later than Saturday, 7th February, 1959.

A. H. JOLLIFFE,
Clerk of the Board.

Liverpool Road,
Great Sankey,
Warrington.

E9717

CENTRAL ELECTRICITY GENERATING BOARD

SOUTH WALES DIVISION

ASSISTANT MAINTENANCE ENGINEER (MECHANICAL)

VACANCY NO. 13 E 59

Applications invited for the superannuable N.J.B. appointment of ASSISTANT MAINTENANCE ENGINEER (MECHANICAL) at Tir John Power Station, Swansea.

Salary : H 9 £910 to £955 per annum.

Applicants should have experience in the maintenance of heavy plant and possess H.N.C. or equivalent qualifications.

Special application forms obtainable from Secretary, South Wales Division, Central Electricity Generating Board, Twyn-y-Fedwen Road, Gabalfa, Cardiff, to be returned by the 2nd February, 1959.

E9718

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

DOUNREAY EXPERIMENTAL REACTOR ESTABLISHMENT

ENGINEERING AND TECHNICAL STAFF

ENGINEERING AND TECHNICAL STAFF are required in the Engineering Division of the Dounreay Experimental Reactor Establishment.

(a) INSTRUMENT MAINTENANCE ENGINEERS (Ref. 2853/J1)

to be responsible to a senior engineer for instrumentation on nuclear reactor fuel element development and processing plant, and control of an instrument workshop.

A recognised engineering apprenticeship or comparable training, and Corporate Membership of a Senior Engineering Institution or equivalent are essential. Experience in servicing and repair of industrial and laboratory instruments and controls from the following range is required :—Indicators, recorders and controllers used with detecting elements for pressure, flow and temperature ; electronic equipment for nuclear radiation, chemical analysis and closed circuit television.

Salary between £815 (at age 25) and £1270 or £1300 and £1740, according to qualifications and experience.

(b) INSTRUMENT MAINTENANCE TECHNICIANS (Ref. 2854/J1)

to be responsible to a shop manager either for supervision of a small team engaged on instrument maintenance of nuclear reactors and fuel element development plant and laboratories, or for instrument repair workshop services.

Applicants must have served a recognised engineering apprenticeship or have received comparable training, and have considerable experience of instrument servicing and repair, covering indicators, recorders and controllers used with detecting elements for pressure, flow and temperature, and electronic equipment for nuclear radiation, chemical analysis and closed circuit television. Possession of an O.N.C. or equivalent may be an advantage.

Salary £875 (at age 30 or over) to £1050.

(c) DESIGN ENGINEERS

(i) to be responsible to the engineer in charge of a team engaged on design of experimental apparatus, required for a programme of irradiation research in the Materials Testing Reactor.

Considerable experience in the field of engineering design and development is required (ref. 2857/J1).

(ii) To join a team responsible for analysing the engineering performance of the Fast Reactor and for design studies on future Fast Reactor systems.

Applicants must be capable of analysing performance and executing design work on Fast Reactor cooler circuits, including core, heat exchanger, and valve and pump design in their more fundamental aspects. A knowledge of hydraulic and thermal calculations, together with experience of heat exchanger design, would be an advantage (ref. 2875/J1).

A recognised engineering apprenticeship and Corporate Membership of a Senior Engineering Institution are essential for both posts.

Salary between £1300 and £1740, according to qualifications and experience.

(d) ASSISTANT DESIGN ENGINEER (Ref. 2876/J1)

to be responsible to a design engineer for leading a small team of draughtsmen engaged on design and detail of a wide variety of mechanical work in laboratories, reactors and associated chemical plants.

Applicants must have served a recognised engineering apprenticeship, possess H.N.C. or equivalent, and have had some drawing-office experience.

Salary between £880 and £1270, according to qualifications and experience.

(e) EXPERIMENTALISTS (Ref. 2856/J1)

to assist a team of engineers in the testing of experimental apparatus and components for use in the Materials Testing Reactor as part of a research programme into the effects of radiation on materials.

G.C.E. or equivalent in five subjects, including two at Advanced Level in Science or Mathematics, is essential, together with experience in the field of experimental engineering or development. Possession of H.N.C. or equivalent may be an advantage. Normal minimum age 26 years.

Salary between £990 and £1215, according to qualifications and experience.

Contributory superannuation. Staff housing scheme. Hostel accommodation may be available.

Send postcard for application form, quoting appropriate reference, to Personnel Manager, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, INDUSTRIAL GROUP, D.E.R.E., Dounreay, Thurso, Caithness, Scotland.

Closing date : 2nd February, 1959. E9667

BOROUGH OF MANSFIELD

ENGINEERING ASSISTANTS

Applications are invited for the following appointments :—

(a) JUNIOR ENGINEERING ASSISTANT

Salary A.P.T. I, £575 by £30 to £725.

Applicants must have completed professional training in accordance with the Scheme for the Training of Municipal Engineers.

(b) GENERAL ENGINEERING ASSISTANT

Salary (1), A.P.T. I, £575 by £30 to £725, or (2) Special Grade, £750 by £40 to £1030.

Salary (1), commencing at a point appropriate for experience and qualifications, will be paid to holders of the intermediate examination of the Institution of Municipal Engineers or a Degree in Engineering, and salary (2) to holders of the Final Examination of the Institution of Civil Engineers or the Institution of Municipal Engineers, or to University Graduate Assistants who have had at least five years' experience (including period of training).

Applications, stating age, training, qualifications, present and past appointments, with salaries, experience and names and addresses of not more than three referees, should be sent to the Borough Engineer and Surveyor, Carr Bank, Mansfield, to arrive not later than Monday, 26th January, 1959.

A. C. SHEPHERD,
Town Clerk.

Carr Bank,
Mansfield.

E9637

PUBLIC APPOINTMENTS

MINISTRY OF SUPPLY

SHREWSBURY, SHROPSHIRE

TECHNICIAN

Ministry of Supply require TECHNICIAN at Shrewsbury, Shropshire, to be responsible for supervision of approved inspection organisation at the works of contractors engaged on the development and manufacture of electrical and electronic equipment for guided weapons. Qualifications : recognised engineering apprenticeship or equivalent training in an appropriate trade. Sound knowledge of light electrical engineering with some electronics experience is required, and a knowledge of computers and high-frequency techniques an advantage. Possession of O.N.C. (Electrical), appropriate C. and G. Final Certificates, or equivalent qualifications desirable. Salary : £820 (aged 30) to £974 p.a.—Application forms from Ministry of Labour and National Service, Railway Street, Wolverhampton, quoting P.E.2096/624. Only those applicants selected for interview will be advised. E9695

PUBLIC APPOINTMENTS

SOUTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD

ENGINEERING ASSISTANT (ELECTRICAL)

Applications are invited for the following appointment on the permanent staff of the Board's Regional Engineer's Department generally in accordance with Whitley Council conditions of service.

ENGINEERING ASSISTANT (Electrical). Commencing salary within the scale : (i) £525 (at age 21 or over) by £20 (4) by £25 (5) to £730 for candidates possessing O.N.C. or equivalent or (ii) £655 (at age 23 or over) by £25 (4) by £30 (1) by £35 (4) by £40 (1) to £965 for candidates possessing H.N.C. or equivalent.

London Weighting of £20–£40 p.a. payable in addition.

Application forms obtainable from the undersigned at 40, Eastbourne Terrace, W.2, to be returned completed by not later than 2nd February.

E9722 E. G. BRAITHWAITE, Secretary.

A.E.R.E. HARWELL | REACTOR SERVICES

PROFESSIONAL ENGINEERS are required to be responsible to a Senior Engineer for the supply of equipment and manufacturing work for reactor installations and experimental equipment. This involves planning and progressing of work and materials supply, technical contractual control, inspection arrangements and organisation and management.

Salary : up to £1740 (Engineer II or III) depending on age and experience.

Please send a Postcard to the Group Recruitment Officer (1302/25), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks, for details.

E9665

MINISTRY OF WORKS

REQUIRES

ENGINEERING DRAUGHTSMEN IN THE FOLLOWING CATEGORIES

HEATING AND VENTILATING

Design of all types of installations, including air conditioning.

ELECTRICAL

Design of lighting, power and special type installation, and site distribution schemes.

STRUCTURAL

Design and detailing of reinforced concrete or structural steelwork.
For employment in LONDON and PROVINCES on major site developments and all classes of PUBLIC and INDUSTRIAL BUILDING.

GENERAL CONDITIONS

Salary range £550 (age 21) to £870 p.a. in London (slightly less elsewhere). Starting point according to age, qualifications and experience ; 5-day week ; 3½ weeks' annual leave initially, and concessions for higher technical training in approved cases. Prospects of promotion to posts with salaries of £1015 p.a. and above. Opportunities for permanent posts leading to pensions, non-contributory.

QUALIFICATIONS

Technical education to O.N.C. or equivalent standard.

APPLICATIONS

State age, experience, training and qualifications, to : The Chief Engineer, Ministry of Works Room 435, Abell House, John Islip Street, LONDON, S.W.1.
Interviews at Regional Offices when possible.

E9500

EDUCATIONAL

ENGINEERS

Train for Technical Teaching

Technical Teaching offers excellent prospects, good salaries, and security.

APPLICATIONS are invited from ENGINEERS for TRAINING as FULL-TIME TEACHERS IN TECHNICAL COLLEGES.

The next course of training will begin in SEPTEMBER, 1959 and end in JUNE, 1960.

Applicants should :

1. Be between about 25 and about 45 years of age.
2. Have Industrial experience.
3. Possess one of the following :
   Higher National Certificate,
   Full Technological Certificate of the City and Guilds of London Institute,
   Professional Qualifications or Degree.

SUBSTANTIAL GRANTS AVAILABLE—FREE OF INCOME TAX—NORMALLY FREE TUITION, BOARD AND LODGING.

Write for details and an Application Form to one of these Colleges :

The Director (E.1.10),
Bolton Training College,
Manchester Road,
BOLTON.

The Principal (E/1/10),
Garnett College,
83, New Kent Road,
LONDON, S.E.1.

The Director (E.1.10),
Huddersfield Training College,
Holly Bank Road,
Lindley, HUDDERSFIELD.

E9664 E

BOOKS and PUBLICATIONS

A FIRST YEAR ENGINEERING DRAWING

By A. C. Parkinson, F.I.E.D., etc. 6th Edition. Probably the most famous of all engineering drawing textbooks. It is an essential textbook for all first year students taking the O.N.C. in Mechanical and Electrical engineering. 9/-.

DIESEL PLANT OPERATORS' HANDBOOK

By A. K. L. McCrone, G.I.Mech.E. Here is a handy reference book that has been written specially for the operator of Diesel-Electric Power Plant. It gives in a concise and simplest possible form the essential facts about the equipment he uses. Theory and practice have been blended as far as possible. (Published on behalf of Blackstone & Co., Ltd.) 20/- net.

THE PUMP USERS' HANDBOOK

Compiled on behalf of The British Pump Manufacturers' Association by Herbert Addison, O.B.E., M.Sc., etc. Sponsored by members of the B.P.M.A., this new handbook offers direct help and guidance to owners and users of pumping plant. Covers installation, maintenance, performance, cavitation, pressure-surges, etc. 30/- net.

METAL RECTIFIER ENGINEERING

By E. A. Richards, M.B.E., A.C.G.I., etc. Discusses in detail the principles underlying the operations of metal rectifiers. It forms an essential book for engineers who want to select the right type of rectifier for a particular job, and avoid the disappointments that can ensue from incorrect working conditions. 37/6 net.

PITMAN | *Parker St., Kingsway, London, W.C.2*

HMSO

Crushing and Grinding

Crushing and grinding are among the oldest of human occupations and are probably the most widespread operations in industry. There is an extensive literature on these subjects, and this bibliography contains some 2800 references, with abstracts and annotations, classified under heads, and ranging from theoretical aspects to health and fire risks of the operations.

Price 35s. (*post* 1*s.* 9*d.*)

From the Government Bookshops
or through any bookseller

HMSO

New Books

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E102 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A.B.C. COUPLER AND ENGINEERING CO., LTD., require an ENGINEER with general railway experience to take control of design and development on technical side of components of rolling stock, &c. Write particulars of training and experience, salary required, to The Secretary (Confidential), Fallings Park, Wolverhampton. E9671 A

A CIVIL ENGINEER is required by an engineering and contracting office on N.E. Coast. Applicants should have sound practical experience in reinforced concrete work, both foundations and superstructures, and be Chartered or Graduate Civil Engineers. A 5-day week and a superannuation scheme are in operation.—Apply, stating experience, qualifications, age and salary required, BOX No. E2262, "The Engineer." A

A DESIGNER/DRAUGHTSMAN (MECHANICAL) is required by Michelin Tyre Company, Ltd., for interesting project work at their Stoke-on-Trent factory.

Applicants should have served a sound engineering apprenticeship in this country, possess H.N.C. (with Heat Engines, Applied Thermodynamics, or Steam Engineering, endorsement preferred) and have had experience of problems involving industrial steam applications and pumping systems.

The appointment is permanent and pensionable. A 5-day, 40-hour week and 3 weeks' annual holiday in force.

Housing assistance given if necessary. Tax free allowance of £4 per week for married men pending removal. Company pays removal charges.

Please write to MICHELIN TYRE COMPANY, LTD. (SPA Dept.), STOKE-ON-TRENT, STAFFS, quoting Ref. B/305/TE.

E9639 A

A TECHNICAL ASSISTANT, aged 21–28, required for firm of brewery engineers in Central London. Duties include performance estimates involving heat balance calculations and technical correspondence requiring a knowledge of general engineering practice. Technical education at least to O.N.C.—Applications to BOX No. E2260, "The Engineer." A

AN ASSISTANT MECHANICAL ENGINEER—28 to 35 years of age—is required for an oil refinery. His immediate duties will relate to inspection and preventive maintenance. Applicants should therefore have had experience of this work in chemical works or refineries. The commencing four-figure salary will depend upon experience and qualifications. The position offers excellent future prospects, but candidates must be University graduates and, preferably, Corporate Members of a Professional Institution. Non-contributory superannuation scheme.—Applications should be addressed to the Refinery Manager, Lobitos Oilfields, Limited, Ellesmere Port, Cheshire. E9670 A

ASSISTANT ENGINEER for Sheffield steel works. Applicant should have experience with :

Steel melting plant.
Rolling mills.
Forges.
Steel and hydraulic Engineering.

Write, stating qualifications and experience, to BOX B.554, c/o Streets, 110, Old Broad Street, E.C.2. E9710 A

ASSISTANT WORKS MANAGER required by old-established medium-heavy precision engineers on Merseyside. Pension scheme and prospects for right man. Applicants, not over 45, must have sound production engineering and production control experience, and have held a senior executive position. Reply, stating age, details of experience, and salary required, to Managing Director, BOX No. E2266, "The Engineer." A

DESIGN DRAUGHTSMAN required for shipyard in Renfrew. Applicants preferred in 25–30 age group and should have a B.Sc. Degree or H.N.C. in Mechanical Engineering. It would be an advantage to have experience in marine installations for diesel and diesel-electric small craft. Appointment would offer advancement opportunitie and is pensionable.—Applications, giving full details of career and age, to BOX No. E2263, "The Engineer." A

SITUATIONS VACANT

CRANE DESIGNER/DRAUGHTSMAN, preferably with shop and estimating experience.—IRVINGS, WOODCHESTER, STROUD, GLOS. (Amberley 3163/4 E2235 A

DESIGN ENGINEER

A progressive Engineering Works on the North East coast, specialising in Gearing and Gear Units, wish to appoint an experienced DESIGN ENGINEER for interesting Design and Development work, including supervision of laboratory tests. The position offers excellent prospects, and staff conditions include comprehensive superannuation and bonus schemes and consideration towards housing assistance.—Written applications, giving fullest details, should be sent in confidence to BOX No. E9692, "The Engineer." A

DRAUGHTSMAN required for design and detail work concerned with major development schemes. Must have good experience in the design and installation of mechanical handling plant, and be able to carry out simple survey and site measuring work.—Written aapplication containing full details should be made to the Development Manager, Tarmac Roadstone, Ltd., Ettingshall, Wolverhampton. E9677 A

ELECTRIC ARC MELTING SHOP SHIFT MANAGER for large steelworks in the Midlands. Applicants, aged 30–40, should have a metallurgical training with practical experience in an electric melting shop. Salary according to qualifications and experience. Pension and free life assurance scheme in operation. Full details of age, experience and qualifications.—BOX No. E9497, "The Engineer." A

ENGINEERS AND PHYSICISTS

OPERATIONAL RESEARCH provides a stimulating career for those who do not want to work within the narrow confines of their speciality. The work involves the development of scientific techniques in the general area of decision making and offers a real intellectual challenge with excellent career prospects. Candidates should have a good class Honours Degree in Engineering or Physics and, if possible, some post-Graduate experience. Applications are welcomed from students expecting to graduate this year. Appointments (superannuable) according to qualifications and experience within scale £690–£1200.—Further information and application forms may be obtained from Staff Department (X.1368G.), National Coal Board, Hobart House, London, S.W.1, before 3rd February, 1959.

E9694 A

ESTABLISHED CITY IMPORT EXPORT FIRM has vacancy for an active and enterprising man experienced in export sales of engineering products, particularly the machine tool and automotive fields. Applicants must have at least sound general engineering background coupled with the commercial acumen required to expand business in this field. Remuneration in accordance with ability and experience.—BOX No. E9701, "The Engineer." A

EXPERIENCED STRESSMAN required by large Engineering Company in Birmingham area for interesting work connected with design and development of all types of Railway Rolling Stock. Experience of this particular branch of engineering not essential. Salary commensurate with ability and experience.—Apply BOX No. E9684, "The Engineer." A

HEAVY ROLLING MILLS SHIFT MANAGER, aged 28–35, required by large steelworks in the Midlands. Applicants with an engineering background and previous experience of rolling mill supervision will be given preference. Staff position, pension and free life assurance scheme. Full details of age, experience and qualifications.—BOX No. E9659, "The Engineer." A

MECHANICAL AND STRUCTURAL ENGINEERS are required for analytical and experimental work connected with the design of nuclear power stations. The work includes the design of complex steel structures, stress analysis of shells, evaluation of temperature stress distributions, mechanical vibrations, and pipework calculations. For some posts an Honours Degree is required, for others a Degree is desirable, but candidates with the Higher National Certificate will be considered if they have several years' appropriate industrial experience. These posts are ideal for imaginative young men interested in entering a new and rapidly expanding industry and who wish to make full use of their academic training.—Apply Personnel Manager (DWB), The General Electric Company, Limited, Erith, Kent. E9696 A

MIDLAND FIRM REQUIRES DESIGN ENGINEER with modern experience in the design of centrifugal compressors. Good academic qualifications, together with sound knowledge of the thermodynamic and mechanical problems involved, are required. This post offers the interest and responsibility of a new project, with excellent opportunities in a Company where personal contact will be made with all departments at all levels.—Please write giving full details to BOX No. E9691, "The Engineer." A

RUSTON AND HORNSBY, LIMITED, LINCOLN

There is a vacancy in the Gas Turbine Drawing Office at Lincoln for a CONTRACT AND APPLICATION DRAUGHTSMAN to fill a senior post.

He will be responsible for applying various designs of turbo machinery for installations on land, sea and mobile units throughout the world.

At least 5 years' drawing office experience is essential and the successful applicant will be capable of supervising the work of juniors.

The salary will be according to qualifications and experience, and there is a generous pension scheme.

Applications to Manager, Industrial Relations Department.

E9676 A

Classified Advts. continued on page 114

SITUATIONS VACANT

OPENING FOR A MAN to help on both technical and commercial sides of small individual firm of mechanical engineers in Yorkshire. Must be a live man who would attend to detail and someone used to working with the principal of a small firm. —State age, experience and present salary.—BOX No. E9561, "The Engineer." A

POWER JETS have a vacancy for a SENIOR DESIGN ENGINEER at their Consultancy Dept. at Farnborough, Hants. The position offers exceptional opportunities for experience over the entire field of gas turbine technology as well as good salary and superannuation, and excellent working conditions. Applicants should be about 30–35 with several years' experience of the aerodynamic design and testing of compressors or turbines.—Full details in confidence to the Secretary, Power Jets (R. and D.), Limited, 25, Green Street, London, W.1. E9713 A

J. SAINSBURY, LTD.,
Food Manufacturers and Distributors,

with headquarters at Blackfriars, London, invites applications for an

ADDITIONAL ENGINEER

in the Building and Engineering Division.

The appointee will be employed on development work on projects as they arise in various parts of the business connected with handling, processing or prepacking of food products. He will be responsible for developing equipment and planning layout of a project to which he has been assigned and for working with consulting engineers or architects as necessary.

Applicants should have a thorough technical education to University Degree level or its equivalent, preferably, but not necessarily, in Chemical Engineering, with experience in development work and mechanical handling. Food experience, whilst not essential, would be an advantage. Salary will be according to qualifications and experience with a minimum of £1350 per annum.

The post is permanent and there is a contributory pension scheme.

Applications, giving details of age, education, qualifications and experience, should be addressed to :

The Personnel Manager (E),
J. Sainsbury, Ltd.,
Stamford House, Stamford Street,
LONDON, S.E.1.

E9666 A

SALES ENGINEER required by old-established manufacturers of rotary printing machinery for their London Office. Applicants must have had good experience in the design of rotaries and be capable of analysing printers' requirements and promoting sales of new types of machinery. Preferably 30/40 years of age, and possess technical qualifications comparable A.M.I.M.E. This is an excellent opportunity for a qualified man with practical knowledge of the printing trade, and the post is pensionable.—Reply, stating age, details of experience and salary required to Managing Director, BOX No. E9631, "The Engineer." A

SENIOR AND JUNIOR DRAUGHTSMEN required. Experience in mechanical handling plant an advantage. Good prospects.—BRITISH INDUSTRIAL SAND, LTD., High Street, Godstone, Surrey. E9588 A

SENIOR ENGINEERING LECTURER required to take charge of Cadet Training Course on modern cargo motor liner specially equipped for the purpose, plying between the U.K. and Australia and New Zealand ports. Duties will include teaching, direction of staff and responsibility for progress of thirty Cadets studying on a two-year Course for the Engineering Institutions Part 1 Examination. Applicants should have Graduate qualifications and at least four years' teaching experience in a Technical College or similar Institution. Full pension facilities are available and applicants should therefore be not more than forty years of age. They will also be expected to take part in the social life of the Officers and Cadets, both ashore and afloat. Apply before 15th February, 1959, to The Superintendent Engineer, The New Zealand Shipping Company, Ltd., Royal Albert Dock, London, E.16, giving full particulars of experience, &c., and stating salary required. E9611 A

SENIOR ENGINEER required for research into the performance and utilisation of machine tools. Experience or knowledge of work study and production cost analyst would be advantageous. Work involves the acquisition of synthetic data and its application to economic studies of production operations, including numerically-controlled machining. Excellent working conditions in pleasant surroundings. Pension scheme. Removal expenses paid.—Send full details, including qualifications, experience and present salary in confidence.—BOX No. E9636, "The Engineer." A

SUPERINTENDENT OF WAY AND WORKS required for maintenance of Railway way and works and for supervision of new works with British company operating Railway and Harbour in Goa, Portuguese India. The post is temporary for approximately two years. Salary, £2100, plus one single increment of £100 after one year's satisfactory service. Free quarters. A knowledge of the Portuguese language would be desirable.—Apply, Sir Bruce White, Wolfe Barry and Partners, 1, Lygon Place, Grosvenor Gardens, London, S.W.1 (Tel.: Sloane 3433). E9703 A

TECHNICAL SALES REPRESENTATIVE required by large firm power transmission engineers, London area. Applicants must have practical drawing-office and workshop experience. Sales experience not essential. Full details age, qualifications and past experience.—BOX No. E9674, "The Engineer." A

YOUNG MEN, aged 22 to 26, are required to train as SHIFT MANAGERS for an electric furnace melting shop in the Midlands. Applicants should have a metallurgical training, with H.N.C. or equivalent, and with some practical experience in an electric melting shop. Salary according to qualifications and experience. Staff position, pension and free life assurance scheme. Full details of age, qualifications and experience.—BOX No. E9499, "The Engineer." A

SITUATIONS VACANT

DRAUGHTSMEN

Several Senior Material Handling Design and Layout DRAUGHTSMEN required for a Drawing Office in Canterbury.

Also a number
of
Senior Heavy General Engineering (Design) DRAUGHTSMEN for work in connection with Nuclear Power Plant and other General Engineering work.

Good salaries for men with the right experience.

Five-day week. Pension Scheme.

Apply, stating age, training, experience and salary required, to the Drawing Office Manager, The General Electric Company, Ltd., Leigh House, St. Dunstan's Street, Canterbury, Kent.

E9675 A

MECHANICAL ENGINEER

W. H. Allen Sons & Company Limited, Bedford, require a Senior Mechanical Design Engineer for their Servomechanisms and Control Systems Design Department. Applicants should have a Degree in Mechanical Engineering and Graduate or Corporate Membership of the I.Mech.E. The preferred age range is 27 to 35.

The successful candidate will be responsible for design and development work involving control theory as applied to hydraulic-mechanical systems, including, for example, high-performance prime-mover governing. He will be expected to co-operate with other staff on projects involving the use of electro-mechanical and electronic devices. There is a well-equipped departmental laboratory.

An excellent pension scheme is in operation and assistance with removal expenses will be given.

Applications should be sent to the Personnel Manager, quoting full details of education, qualifications and experience, and stating age and present salary. E9704 A

PA

Personnel Administration Limited

MANAGEMENT CONSULTANTS

Our Appointments Division has been asked to advise on the following post

GENERAL WORKS MANAGER

for a well-established engineering company in the East of Scotland.

Applications are invited from men between the ages of 38 and 45 holding university degrees in engineering, who can offer wide experience of production management at a senior level in the heavy engineering industry. A knowledge of work study and production control methods would be desirable.

A substantial starting salary commensurate with this important post is offered, and there is a pension scheme.

No information is passed to clients without permission of candidates, who should forward brief details, quoting Ref. No. 3233/TE, to:

PERSONNEL ADMINISTRATION LIMITED

APPOINTMENTS DIVISION

2 ALBERT GATE, LONDON S.W. 1

E9697 A

SITUATIONS VACANT

SMITHS MOTOR ACCESSORY DIVISION

SENIOR MECHANICAL AND ELECTRICAL ENGINEERS

We need, in our Development Departments, SENIOR MECHANICAL and ELECTRICAL ENGINEERS for work on instruments and mechanisms.

Applicants should be suitably qualified, will probably have served an apprenticeship and progressed through workshop and Drawing Office to development work associated with mechanical or electro mechanical mechanisms.

Excellent working conditions with a four-figure salary make employment with this Company an attractive proposition.

If you are interested and suitably qualified, write in confidence with details of age, experience and present salary to :

THE STAFF MANAGER,
S. Smith and Sons (England), Ltd.,
Cricklewood Works,
LONDON, N.W.2.
Quoting ref. SM/152 E9721 A

ENGINEERS FOR SOUTH AMERICA

A Canadian company is seeking MECHANICAL ENGINEERS for important positions in large steam power station in Maracaibo, Venezuela. Applicants should be corporate members of the Institution of Mechanical Engineers or hold a University Engineering degree or Higher National Certificate in Mechanical Engineering. Minimum experience 5 years in responsible position in a steam station of 50MW or larger. Knowledge of Electrical Engineering and Spanish desirable but not essential.

Arrangements will be made to interview successful applicants in the U.K. in February.

Positions are permanent and carry starting salaries $9500 to $14,000 per annum depending on experience.

Please give full details of age, education, qualifications and experience. —Address applications to : Dept. M.E.C., Canadian Dept. of Labour, 61, Green Street, London, W.1. E9706 A

STEAM TURBINE DESIGN ENGINEER

Several vacancies exist at Pametrada Research Station for DESIGN ENGINEERS who are interested in marine propulsion. The work is of an advanced nature and a great variety of problems are dealt with, including aerodynamic design and stressing, vibrations, heat balances, &c. Applicants should have a good Engineering degree or equivalent qualification. Some knowledge of marine work will be an advantage. Starting salary will range from £1000 to £1500 depending on age, qualifications and experience. Staff Pensions Scheme and good working conditions.—Apply in confidence to the Director, Pametrada Research Station, Wallsend, Northumberland.

E9626 A

BRITISH-AMERICAN TOBACCO COMPANY LIMITED

RESEARCH & DEVELOPMENT ESTABLISHMENT SOUTHAMPTON

RESEARCH & DEVELOPMENT ENGINEERS

Aged 25–30 required for interesting work on problems connected with the processing of tobacco, and manufacture of cigarettes, affording ample opportunity for personal initiative in research into new processes, plant machinery, their development and evaluation. Candidates should possess a degree in Mechanical or Chemical Engineering, or equivalent qualifications. Industrial experience in the Food Industry would be an asset. Salary will be commensurate with ability and qualifications.

Apply, giving full details of career to Personnel Department (No. 11), British-American Tobacco Company, Ltd., Westminster House, 7, Millbank, London, S.W.1.

E9668 A

SITUATIONS VACANT

WORKS MANAGER

Old-established engineering works in London employing approximately 1000 personnel, require a Works Manager. Candidates must have had good experience in the engineering industry of administration, methods, planning and labour control, especially in the production of medium to heavy machine tools. Technical qualification to at least Higher National Certificate standard is essential. Write, stating age, education, qualifications and brief details of present and past employment with salaries earned.—BOX No. E9699, "The Engineer."

A

SITUATIONS VACANT

The Office of Electricity in the Lebanon seeks

EXPERIENCED ENGINEER

able to assume the responsibilities as

CHIEF OF A STEAM GENERATING STATION

Send offers with curriculum vitæ, stating conditions, to P.O.B. 131, **BEYROUTH.**

E9710 A

SITUATIONS VACANT

JOSEPH LUCAS LIMITED

Manufacturers of Aircraft and Motor Equipment require

FULLY EXPERIENCED

DESIGNERS

Preference will be given to applicants who are conversant with gas turbine combustion equipment or have experience of heat exchangers, ventilating practice, fans and oil firing equipment. Consideration will also be given to persons with good mechanical experience who could quickly adapt themselves to a wide range of products requiring initiative and drive. It is essential that applicants should hold the Higher National Certificate or possess similar qualifications.

This is a well-paid position, offering excellent chances of promotion. A generous Pension Scheme is in operation.

Apply NOW to the Personnel Manager, Harpher Clough Works, Burnley.

E9685 A

SITUATIONS VACANT

ASSISTANT ELECTRICAL DESIGNER

required by

W. H. ALLEN SONS & CO., LTD., BEDFORD

A candidate with experience in the design of medium-size A.C. and D.C. motors would be specially welcome; knowledge of production and A.C. commutator motors would be an advantage. Consideration would be given to applications from graduates who have not yet had much practical experience.

The post is one which offers scope for initiative and will entail research and development.

Applications, giving full particulars of experience, should be sent to the Personnel Manager, Queens Engineering Works, Bedford.

E9669A

SITUATIONS VACANT

MACHINE TEST ENGINEER

Applications are invited for an appointment as MACHINE TEST ENGINEER with British Oxygen Engineering, Ltd., who are engaged on the manufacture and installation of Air Separation and Chemical Plant.

Applicants should be qualified to H.N.C. standard or equivalent and have experience in the operation and testing of Rotary and Reciprocating Pumps, High Pressure Compressors and Turbo Machinery. The appointment will be based at Edmonton and will entail plant proving work on the Company's various construction sites.

Excellent salary and conditions of service are offered and assistance with Housing may be given.

Applications, with full details of qualifications and experience should be made to:

Employment Officer (G.4507),

British Oxygen Engineering Limited,

Angel Road, Edmonton, N.18.

E9719 A

SMITHS MOTOR ACCESSORY DIVISION

PROJECT ENGINEER

(OIL BURNING)

Applications are invited from suitably qualified engineers for the above vacancy.

The factory is situated at Witney, 12 miles from Oxford, and a modern house (to rent), will be made available to the successful applicant.

Work includes initiating and progressing development test programmes on light oil-burning equipment.

H.N.C. required, plus apprenticeship, or equivalent. Knowledge of control circuits and equipment essential, also experience on oil-burning equipment.

Salary will be in accordance with experience and qualifications.

Applications in confidence to:

Personnel Manager,

S. Smith and Sons (England), Ltd.,

Motor Accessory Division,

Witney, Oxon.

E9720 A

EXPERIMENTAL AND RESEARCH ENGINEERS

British Nylon Spinners continue to expand and invite applications from Corporate and Graduate Members of the Institution of Mechanical Engineers interested in Experimentation and Research. The work covers a field including Machine Dynamics, Heat Transfer, Servo Control Systems, Electronic Circuit Design, Analogue Simulations and Stress Problems. Each Engineer must be capable of undertaking a variety of such problems for which, primarily, he will be solely responsible. He should have, therefore, high academic qualifications and a real feeling for this type of work. The works are most attractively situated, while conditions of employment are equivalent to the best obtainable. Likely applicants will be invited to meet the Engineering Staff in order to discuss the work.

Rented houses may be made available to married staff, while assistance is given with removal expenses.

Please write, quoting Ref. 2/E/160, to:—

The Personnel Manager,

BRITISH NYLON SPINNERS,

Pontypool, Monmouthshire.

E9679 A

MECHANICAL AND STRUCTURAL ENGINEERS

OPPORTUNITIES WITH

MARCONI'S WIRELESS TELEGRAPH CO. LTD.

Mechanical Engineering problems of great variety and complexity result from new techniques in radar, communications and broadcasting in which this Company is pre-eminent. A realignment and expansion of our Mechanical Engineering activities is now taking place.

There exist a number of vacancies for:

QUALIFIED MECHANICAL AND STRUCTURAL ENGINEERS working under the direction of the CHIEF MECHANICAL ENGINEER, who is responsible directly to the Managing Director.

The work will extend from Applied Research to Product Development and Design, and will be carried out at the Mechanical Engineering Laboratory at Chelmsford, and the Mechanical Engineering Works at Newcastle-upon-Tyne. It will cover:

Structural Techniques, Stress Analysis, Application of Conventional and New Materials, Power Transmission, Servo and other Mechanisms, and Heat Transfer,

with the emphasis on fundamental approaches and with scope for unconventional thinking.

ENGINEERS WITH GOOD DEGREES OR EQUIVALENT QUALIFICATIONS and with experience in one or more of these topics, but not necessarily in the electronics industry, are invited to submit details of their qualifications and experience with a view to discussing this opportunity of joining a rapidly expanding organisation.

Please reply to: Mr. G. F. W. Adler, Chief Mechanical Engineer, Department C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference E2700B.

Informal interviews can be arranged, either at Chelmsford or elsewhere.

E9672 A

AIC

DEVELOPMENT ENGINEER (Civil)

GENERAL WORKS MANAGER

As this is a confidential service, the names of applicants will not be disclosed without their agreement

A brief statement of qualifications and experience should be sent to Mr C. J. Duncan, marked T (E) 220 for the Development Engineer, and M(E)291 for the General Works Manager, at

Executive Selection Service *is advising on the following appointments*

based on London, for the Contract Division of a leading Company manufacturing specialised building products. The Development Engineer will be responsible for development and allied work in the Contract Division under the general guidance of the Assistant General Manager. This will include projects that will secure improvements and economies in present methods, as well as in fields that will lead to additional and expanded markets. A salary of £1,250–£1,500 a year will be paid to a young Civil Engineer aged between twenty-six and thirty-three with a good technical background, experience on building or constructional contracts and the ability to develop techniques and processes.

for a Company in West Scotland manufacturing a diverse range of engineering products. The General Works Manager will be completely responsible for the day-to-day running of the factory with direct responsibility to the Board on all policy matters. He should preferably have an Engineering Degree, be an Associate Member of the Institution of Mechanical Engineers and of proved ability in the control of manufacture. The post should lead to a seat on the Board. The starting salary range is £1,750–£2,000 a year, and a pension scheme is in operation.

Associated Industrial Consultants Ltd BUSH HOUSE LONDON WC2

E9709 A

HARVEY

SENIOR MECHANICAL ENGINEERING DRAUGHTSMAN

required for Engineers' Department. H.N.C. standard and preferably with workshop experience of maintenance and development.

Regular employment, superannuation scheme, &c.

Apply, giving full details, to the Personnel Manager, G. A. Harvey & Co. (London), Ltd., Woolwich Road, Charlton, London, S.E.7.

E9708 A

ROBERT STEPHENSON AND HAWTHORNS

requires an

ELECTRICAL ENGINEER

to work as Technical Assistant on development work and technical investigations connected with oil-fired forced circulation Steam Generators.

Candidates should have served an apprenticeship with a firm of repute, and qualifications should include H.N.C. and a thorough knowledge of electric and electronic control equipment as used in modern combustion and water level control systems. In addition, some knowledge of oil burning, steam properties and mechanical design would be useful though not essential.

Salary in accordance with qualifications and experience.

Contributory Superannuation Scheme.

Apply in confidence to: The English Electric Company, Ltd., Dept. C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference E1418A, and giving particulars of age, qualifications and salary required.

E9698 A

SITUATIONS WANTED

FIRST-CLASS ENGINEER, with wide experience mechanical handling plant, structures, hoppers, plate-work fabrications, seeks to represent in London area progressive company. Small office with 'phone established Victoria Street.—BOX No. E2270, "The Engineer." B

FOUNDRY MANAGER DESIRES CHANGE, at present in full control all dept. of large jobbing foundry producing castings up to 40 tons, also mechanised plant. Would consider similar position, home or abroad with progressive firm. Iron, steel, non-ferrous. Ability to build foundry to meet any type of specialised production or modernise existing foundry. Thorough practical and technical knowledge of modern foundry practice. Metallurgical, administration, planning, budgetary control, &c. Results guaranteed. M.I.B.F.—BOX No. E2268, "The Engineer." B

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KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone: Knottingley 2743/4). E116 MW

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FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E103 E

DRAWING & DESIGN SERVICE

QUALIFIED MECHANICAL ENGINEERING DESIGNER, wide experience, wishes to undertake Design/Detail Work. All commissions in strict confidence.—Please write initially to BOX No. E2265, "The Engineer." S

Classified Advts. continued on page 116

AGENCIES

A WELL-KNOWN FIRM OF STEEL FABRICATORS desires to appoint AGENTS, preferably on a commission and expenses basis, for areas other than the Central Midlands. First-class workmanship in a new factory with capacity for machine tool bodies and similar fabrications up to a maximum weight of 12 tons per piece. Competitive prices and good deliveries are quoted and customers already include many well-known firms. Position would suit gentleman calling on heavy engineers and consultants with non-competitive agencies.—BOX No. E2253, "The Engineer." D

WELL-ESTABLISHED FIRM OF FORGEMASTERS wishes to appoint AGENTS for the Northumberland and Durham area on a commission basis. The company are makers of high-quality heavy steel forgings up to a maximum weight of 25 tons each piece mainly for the shipbuilding and heavy engineering industries.—BOX No. E2269, "The Engineer." D

EXPORT NORTHERN EUROPE! Manufacturers or agents requiring full or shared services from SALES REPRESENTATIVE experienced that area, please write BOX No. E2264, "The Engineer." D

BUSINESSES and PREMISES

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Glasgow 12 miles, Edinburgh 35 miles. Approximately five acres in all. Single storey buildings (45,000 square feet). Cranage facilities. Road and rail access. Sidings for up to 100 wagons. Fully equipped for timber wagon repairing. Good class of labour available. Propositions regarding the foregoing to :

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121, WEST GEORGE STREET,
GLASGOW C.2.

E9396 L

MACHINERY Etc. WANTED

WANTED URGENTLY 4/6000kW condensing steam turbo alternator set 6·6kV 3-phase 50 cycles, 380 lb. steam pressure 750 deg. Fah.—BOX No. E9689, "The Engineer." F

TWO SECOND-HAND SURFACE TABLES approximately 12ft. by 10ft. in good condition. Table face to be squared off.—Write 1311, Wm. Porteous and Co., Glasgow. E9683 F

WANTED, MODERN No. 21 COCHRAN VERTICAL BOILER, 105 p.s.i., with fittings, and extended skirt.—BOX No. E9693, "The Engineer." F

FOR SALE

RECTIFIER EQUIPMENT FOR SALE

One Double-Bulb Mercury Arc RECTIFIER and TRANSFORMER EQUIPMENT, together with D.C. Switchboard. Input 415 volts, 3-phase, 50 cycles, output 500/250 volts D.C., 3-wire, capacity 150kW., 300/0/300 amps. continuous. Temporary equipment for change-over.
Apply to J. AND R. TENNENT, LTD., Wellpark Brewery, Glasgow, E.1. E2261 G

L. STORHAUG AND PARTNERS, LTD.

One 3-drum Yarrow type BOILER, 100,000 lb. steam per hour—unused.

Two Ruston and Hornsby DIESEL GENERATING SETS, 300kW., 220 volts, 428 r.p.m.

One 200kVA., 400 volts, 3-ph., 50 cycles, Mirrlees DIESEL GENERATING SET.

25, FINSBURY COURT,
FINSBURY PAVEMENT, LONDON, E.C.2.

E147 G

FOR SALE

Edwards

WESTON Model 400/100 Double-Sided Friction Screw Press, of welded steel plate construction, arranged motor drive for 400/3/50, pressure exerted approximately 120 tons, maximum stroke 11in., diameter of screw with four starts 6¼in., size of bed 21¼in. by 18in. Weight approximately 5 tons.

CRAIG and DONALD Model 400/10 All-Steel, Motorised, Double Geared Press Brake, of steel plate construction, arranged motor drive for 440/3/50, pressure exerted approximately 400 tons, former capacity 10ft. by ¼in., length of top beam and bed 10ft., depth of gap 12in. Weight approximately 29 tons.

BESCO Open-End Angle Iron Bending Machine, type M.14A, arranged motor drive for 380/420/3/50, capacity up to 1¼in. by 1¼in. by ¼in., mounted on baseplate and cast iron floor stand; the upper roll is made to rise so that complete circles may be withdrawn.

TWO NEW TYPE MGA6K Motorised Geared Scrap Shearing Machines, mounted on steel fabricated four-wheel truck for portable use. Suitable for cropping round or square bars, sheet metal, armoured cable and all types of scrap metal. Arranged motor drive for 400/440/3/50.

RUSHWORTH Power-Operated, Double-Geared, Open-Ended Guillotine Shearing Machine, overcrank type, arranged motor drive for 380/440/3/50, capacity mild steel 4ft. by ¼in. Weight approximately 50 cwt.

NEW SIEVERT No. 4H. Flanging Machine, capacity up to 12 S.W.G. mild steel, flange 1¼in. deep can be formed on any size blank over 24in. diameter. Weight approximately 550 lb.

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BIRMINGHAM, 3.
Telephone : Central 7606–8.

E207 G

VALES PLANT REGISTER LIMITED

OFFER FOR IMMEDIATE SALE

CRANES

NEALS 15 cwt. "G" PETROL, 15ft. channel, pneumatics, J.A.P. petrol. £295.
NEALS 1-ton "D" MOBILE, 30ft. swan-neck, Ruston engine, pneumatics. £750.
JONES "Super 20" MOBILE, 24ft. jib, Lister Diesel, solids. £400.
JONES "Super 22" MOBILE, 16ft. cantilever, pneumatics. £950.
VALES-REICH 3-ton 20/1300 Electrically-Operated TOWER. £2750.
NEALS "NMS" 3-ton MOBILE, 30ft. lattice, Ruston engine, pneumatics. £2950.
ANDERSON GRICE 3-ton Electric DERRICK, 120ft. jib, S.L.I. £1600.
JONES KL44 4-ton CRAWLER, 50ft. jib, Ruston engine. £1850.
RUSHWORTH 5-ton Electric DERRICK, 110ft. jib. £2450. Bogies available extra.
SMITH 5-ton Steam LOCOS., 4ft. 8½in. gauge, 35ft. jibs. £850 each.
COLES 6-ton Diesel/Electric MOBILE, 30ft. cantilever, pneumatics.
COLES S.88 6-ton MOBILE, 21ft. 9in. cantilever, solids, Perkins engine. £2250.
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COLES 10-ton Fully MOBILE, 40ft. jib, Perkins engine, pneumatics. £5350.
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Further details, 14, Lower Grosvenor Place, London, S.W.1. Telephone : VICtoria 7531, 3501, 8080, 9886 (15 lines). E107 G

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2500 c.f.m. BELLISS & MORCOM 100 p.s.i. 550 h.p. CROMPTON PARKINSON motor, 3·3kV or 400/440/3/50.
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NEW ELDAIR 6ft. by 14 g. PRESS BRAKE.
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7½-ton Aabacas, Twin Girder, Cab-controlled Overhead Electric Travelling Crane, 31ft. span, 20ft. lift, 400/3/50. New 1953. Recently overhauled.
30 cwt. King, Pendant-controlled Ditto, 27ft. span, 400/3/50. New 1955.
600 h.p. Unused, Totally Enclosed, Oil Cooled Reduction Gear by Turbine Gears, Ltd., Ratio 730/38·7 r.p.m.
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FOUR MODERN 400 h.p. ROLLING MILL DRIVES, each incorporating 400 h.p. English Electric slip-ring motor, 440 volts, 3-phase, 50 cycles, 738 r.p.m., direct coupled to Power Plant gear giving final speed of 30 r.p.m., each motor with twin flywheels having total kinetic energy of 10,000 h.p. seconds, each with barring motor and automatic control gear.

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60-ton Goliath, by Clyde, 40ft. span, 5-ton auxiliary, cab control, 400/3/50.
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Surplus Unused Ministry Cranes, mainly still packed. Drawings on request. Inspection invited. Bargain prices.

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NEW 979kVA. 6·6kV. three-phase, 50 cycles, Diesel engine-driven ALTERNATOR SET, direct coupled at 750 r.p.m., incorporating engine by Mirrlees, Type JV16, 1120 h.p., driving Alternator by Brush Electrical, complete with all standard ancillaries, including starting equipment, cooling water equipment, and control switchboard by Reyrolle.
Ready for immediate delivery.

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ONE VACUUM SHELF DRYER as new, 125 sq. ft. total tray area, complete with oil heating equipment.—BOX No. E9686, "The Engineer." G

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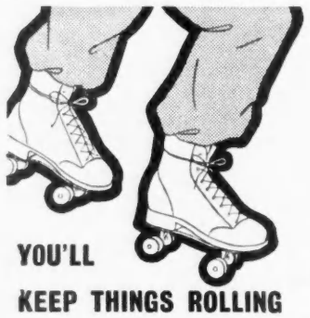

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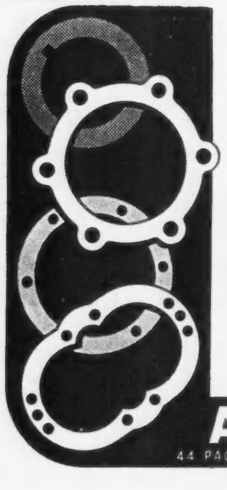

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AIR COMPRESSORS.—Two Belliss & Morcom 2500 c.f.m., 100 p.s.i., 550 h.p. motors ; also Broomwade 500, 400, 300, 200 and 130 c.f.m. all motorised ; and several others of various makes and capacities.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

MOBILE ROAD CRANES.—10-ton Lorain, lorry mounted, 30ft.-70ft. extendible jib ; 10-ton 33 R.B. track mounted, 40ft. jib ; 8½-ton Ransomes Petrol/Electric, 21ft. jib ; 6-ton Coles Diesel/Electric pneumatics, new 1948 (2) ; 6-ton Coles Diesel/Electric, solids ; 4-ton Coles Diesel/Electric, solids, 1945 ; 4-ton Jones KL44, diesel, 1950 ; 3-ton Jones "Super 40" diesel, pneumatics (3) ; 2-ton Jones "Super 20" diesel pneumatics.

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LOCOS.—Fowler diesel, 150 h.p. (2) ; Ruston diesel, 80/88 h.p., new 1942 ; Bagnall 14in. by 22in., two oil fired, one coal ; Peckett steam, 7in. by 12in., 1941 ; also 3 miles track, 24in. gauge Bogies, Turnouts, &c.

STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., 3in. black, new ; 5000ft. 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted ; 216ft., 60in. riveted.

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SALES BY AUCTION

		Main Location	*Auctioneers*
January 29	**Machine tools, plant,** etc.	M.O.S. Sub Depot **Queens Drive, Kilmarnock, Ayrshire.**	**SHIRLAW, ALLAN & CO.** (Dept. L), Keith Street, Hamilton, Lanark. (Tel. : 63.)
February 2-6	**Vehicles, lifting and earth moving equipment, motor cycles,** etc.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel. : 54272.)
February 3-4	**Miscellaneous stores,** including :—	Central Ordnance Depot, **Didcot, Berks.**	**SIMMONS & SONS** (Dept. L), 12, Station Road, Reading, Berks. (Tel. : 54025.)
	Twist drills ; open-end and adjustable spanners ; screw cutting tools ; bolts ; nuts ; screws ; rivets ; carpenters' tools, including large quantity of hand saws ; gravity rollers ; hydraulic jacks ; lifting tackle ; trolleys and trailers ; old canvas ; canvas covers ; cookers ; wooden forms ; folding flat chairs ; wooden packing cases ; camping equipment ; stacking machines ; large quantity of pick-axe heads ; rope ; hessian ; brass eyelets ; vacuum jars ; cycles ; fibreboard boxes ; re-boring machine ; Tangye water pumping sets, etc.		
February 10-11	**Miscellaneous stores,** including large quantity vehicle tyres, etc.	M.O.S. Storage Depot, **Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel. : 4366.)
February 18	**Miscellaneous stores.**	Northern Command Ordnance Sub-Depot, **Barlow, Nr. Selby, Yorkshire.**	**BARTLE & SONS** (Dept. L), 50-52, Merrion Street, Leeds, 2. (Tel. : 2.0898.)
February 20	**Miscellaneous stores.**	Returned Stores Group, Reed Hall, **Colchester.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex (Tel. : 3171.)
February 24-25	**Machine tools, plant and miscellaneous stores.**	M.O.S. Storage Depot, **Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel. : Blackfriars 8373.)

Application for catalogues should be made *only* to the auctioneers shown above (price of catalogues 1s. 0d.—P.O. only.)

E118 I

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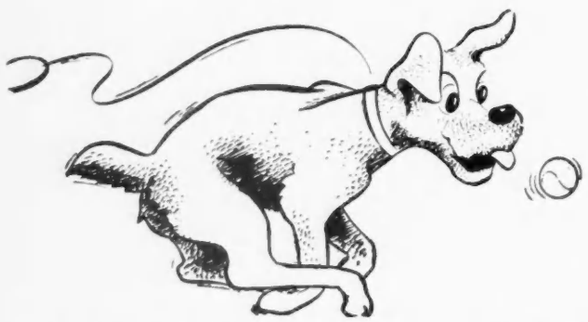

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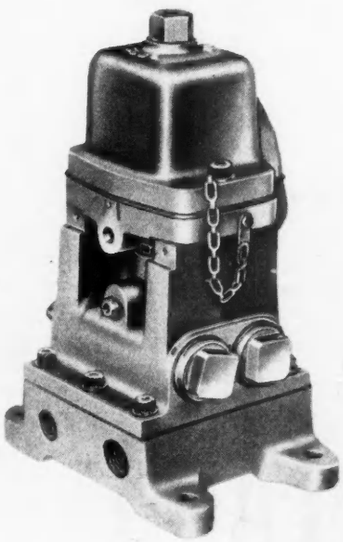

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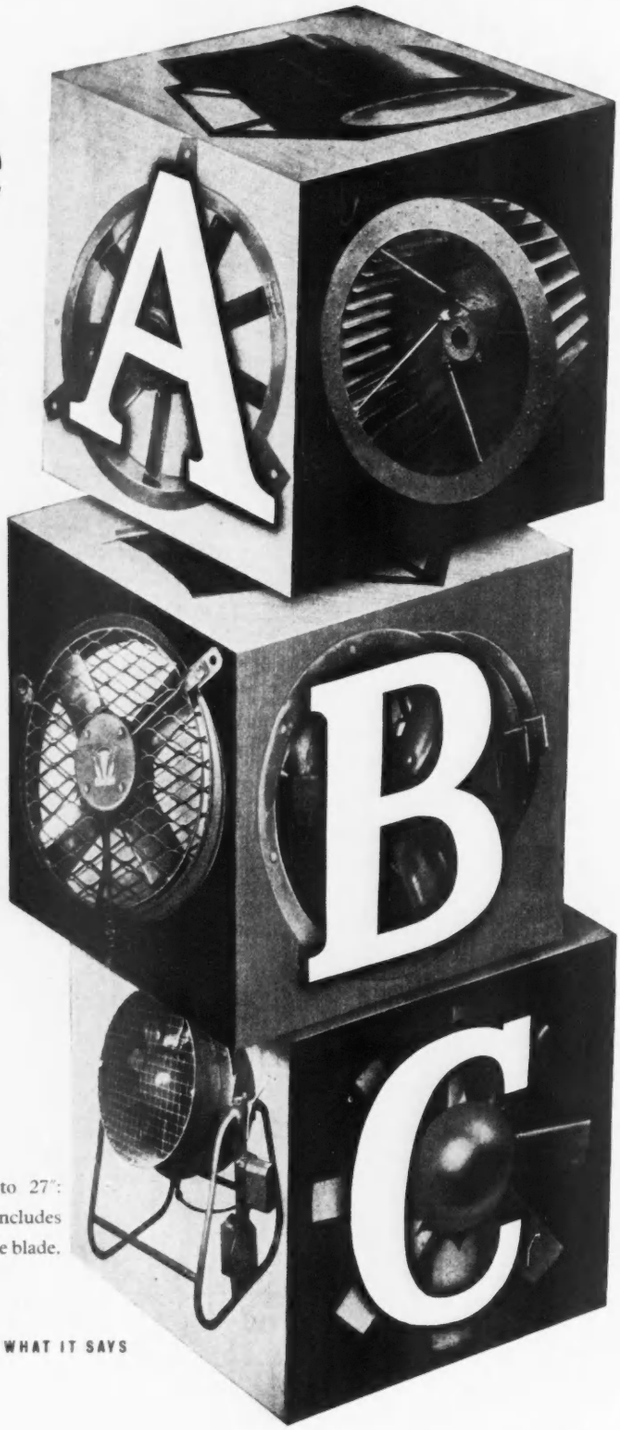

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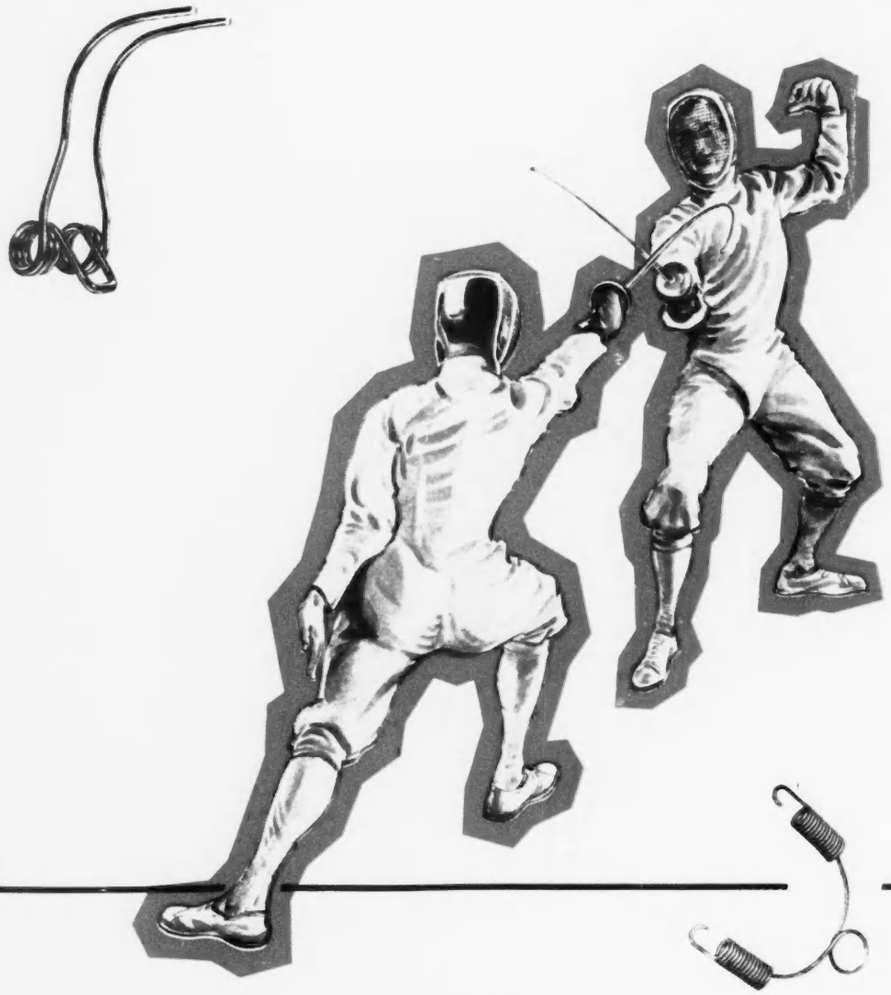

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